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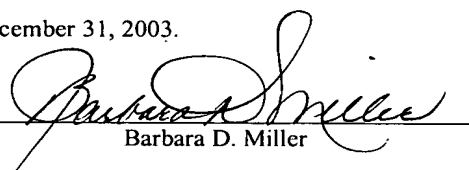
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By: \_\_\_\_\_

  
Barbara D. Miller

**ABSORBENT STRUCTURES HAVING ENHANCED FLEXIBILITY**

by

Jayant Chakravarty

James G. Van Himbergen

and

David L. Zenker

## **ABSORBENT STRUCTURES HAVING ENHANCED FLEXIBILITY**

### **BACKGROUND**

5 The present invention relates to absorbent structures suitable for incorporation into disposable absorbent articles. More particularly, the present invention relates to non-woven absorbent structures having enhanced flexibility.

10 Stabilized absorbent structures are gaining favor among manufactures of disposable absorbent articles. However, many of these stabilized absorbent structures are perceived as lacking in flexibility. Consequently, there remains a need to enhance the flexibility of stabilized absorbent structures.

### **SUMMARY**

15 In response to the foregoing need, the present inventors conducted intensive research and development efforts that resulted in the discovery of unique absorbent structures having enhanced flexibility. The present inventors were further surprised that their discovery could also enhance the flexibility of conventional non-stabilized absorbent structures. Specifically, one version of the present invention provides for an absorbent body suitable for incorporation into a disposable absorbent article. The absorbent body includes a non-woven absorbent structure having a unitary construction and absorbent fibers. The absorbent structure has a longitudinal length, a lateral width and a thickness. At least a portion of the absorbent structure has discontinuous absorbent zones that define at least two channels. In this version, at least one of the channels runs in a longitudinal length direction of the absorbent structure. Also in this version, at least one of the channels runs in a lateral width direction of the absorbent structure. The density of the absorbent structure in the channels is less than or equal to the density of a portion of the absorbent structure adjacent the channels.

25 Another version of the present invention provides for an absorbent article comprising a fluid pervious liner, a liquid impervious outer cover and an absorbent body. The absorbent body is disposed between the liner and the outer cover. The absorbent body includes a non-woven absorbent structure having a unitary construction and absorbent fibers. The absorbent structure has a longitudinal length, a lateral width and a thickness. At least a portion of the absorbent structure has discontinuous absorbent zones that define at least two channels. In this version, at least one of the channels runs in a longitudinal length direction of the absorbent structure. Also in this version, at least one of the channels runs in a lateral width direction of the absorbent structure. The density of the absorbent structure in the channels is less than or equal to the density of a portion of the absorbent structure adjacent the channels.

35 Still another version of the present invention provides for an absorbent body suitable for incorporation into a disposable absorbent article. The absorbent body includes a non-

woven absorbent structure having a unitary construction and absorbent fibers. The absorbent structure has a longitudinal length, a lateral width and a thickness. At least a portion of the absorbent structure has discontinuous absorbent zones that define at least four channels. In this version, at least two of the channels run in a longitudinal length direction of the absorbent structure. Also in this version, at least two of the channels run in a lateral width direction of the absorbent structure. The density of the absorbent structure in the channels is less than or equal to the density of a portion of the absorbent structure adjacent the channels. That portion of the absorbent structure having the discontinuous absorbent zones has a cylindrical compression at yield which is at least 55 percent less than the cylindrical compression at yield of an otherwise similar absorbent structure free of the discontinuous absorbent zones.

### DRAWINGS

The foregoing and other features, aspects and advantages of the present invention will become better understood with regard to the following description, appended claims and accompanying drawings where:

FIG. 1 is a plan view of an absorbent article of the present invention illustrated in the form of a diaper shown unfastened and laid flat;

FIG. 2 is an exploded cross section taken generally in the plane including line 2-2 of FIG. 1;

FIG. 3 is a perspective view of the diaper shown as worn;

FIG. 4 is a longitudinal cross-section of an absorbent structure of the diaper of FIG. 1 taken generally on the longitudinal axis thereof;

FIG. 5 is a schematic perspective of an apparatus for forming an absorbent structure of the present invention;

FIG. 6 is an enlarged side elevation of an airforming device of the apparatus of FIG. 5;

FIG. 7 is a fragmentary cross-section of the airforming device of FIG. 6;

FIG. 8 is a schematic perspective of a forming drum and forming surface of the airforming device of FIG. 6;

FIG. 9 is an enlarged schematic of a portion of the forming drum and forming surface;

FIG. 10 is a schematic perspective of a longitudinal cross-section taken through a portion of the forming drum and forming surface;

FIG. 11 representatively illustrates an absorbent structure, a portion of which has discontinuous absorbent zones that define channels;

FIG. 12 representatively illustrates an absorbent structure, a portion of which has discontinuous absorbent zones that define channels;

FIG. 13 representatively illustrates an example of a formed grid; and

FIG. 14 representatively illustrates an example of a wire grid.

Corresponding reference characters indicate corresponding parts throughout the several views of the drawings.

### DESCRIPTION

5 Referring now to the drawings and in particular to FIG. 1, one example of an absorbent article incorporating the present invention is illustrated in the form of a diaper, which is indicated in its entirety by the reference numeral 21. As used herein, an absorbent article refers to an article which may be placed against or in proximity to the body of the wearer (*e.g.*, contiguous to the body) to absorb and/or retain various waste discharged from  
 10 the body. Some absorbent articles, such as disposable absorbent articles, are intended to be discarded after a limited period of use instead of being laundered or otherwise restored for reuse. It is contemplated, however, that the principles of the present invention have application in garments (including reusable garments) and other absorbent articles. For example, the principles of the present invention may be incorporated into children's training  
 15 pants and other infant and child care products, adult incontinence garments and other adult care products, medical garments, sanitary napkins and other feminine care products and the like, as well as surgical bandages and sponges.

The diaper 21 is shown in FIG. 1 in an unfolded and laid-flat condition to illustrate a longitudinal axis X and a lateral axis Y of the diaper. The diaper 21 generally comprises a  
 20 central absorbent assembly 23 extending longitudinally from a front (*e.g.*, anterior) region 25 of the diaper through a crotch (*e.g.*, central) region 27 to a back (*e.g.*, posterior) region 29 of the diaper. The central absorbent assembly 23 is generally I-shaped, and more particularly hourglass shaped, and has contoured, laterally opposite side edges 31 and longitudinally opposite front and rear waist edges or ends, respectively designated 33 and 35. It is  
 25 understood, however, that the diaper 21 may have other shapes, such as a rectangular shape or a T-shape without departing from the scope of the present invention. The side edges 31 of the diaper 21 extend longitudinally from the front region 25 through the crotch region 27 to the back region 29 for forming transversely spaced leg openings 37 (FIG. 3) of the diaper when worn.

30 The front region 25 generally includes the portions of the central absorbent assembly 23 which extend over the wearer's lower abdominal region and the back region 29 generally includes the portions of the central absorbent assembly which extend over the wearer's lower back region. The crotch region 27 includes the portion extending longitudinally through the wearer's crotch from the front region 25 to the back region 29 and laterally between the  
 35 wearer's legs. As worn on the wearer's body (FIG. 3), the diaper 21 further defines a central waist opening 43 and the leg openings 37.

With particular reference to FIG. 2, the central absorbent assembly 23 of the diaper

21 comprises an outer cover, generally indicated at 49, a bodyside liner 51 positioned in facing relation with the outer cover, and an absorbent body, generally indicated at 53, disposed between the outer cover and the liner. The outer cover 49 of the illustrated embodiment generally defines the length and width of the diaper 21. The absorbent body 53  
5 has a length and width which are less than the respective length and width of the outer cover 49 such that the outer cover extends both longitudinally and laterally out beyond the sides and ends of the absorbent body. The bodyside liner 51 may be generally coextensive with the outer cover 49, or may instead overlie an area which is larger (and would thus generally define the length and/or width of the diaper 21) or smaller than the area of the outer cover 49,  
10 as desired. In other words, the bodyside liner 51 is desirably in superposed relation with the outer cover 49 but may not necessarily be coextensive with the outer cover.

In one embodiment, the outer cover 49 is stretchable and may or may not be somewhat elastic. More particularly, the outer cover 49 is sufficiently extensible such that once stretched under the weight of the insulated absorbent body, the outer cover will not retract  
15 substantially back toward its original position. However, it is contemplated that the outer cover 49 may instead be generally non-extensible and remain within the scope of this invention.

The outer cover 49 may be a multi-layered laminate structure to provide desired levels of extensibility as well as liquid impermeability and vapor permeability. For example,  
20 the outer cover 49 of the illustrated embodiment is of two-layer construction, including an outer layer 55 constructed of a vapor permeable material and an inner layer 57 constructed of a liquid impermeable material, with the two layers being secured together by a suitable laminate adhesive 59. It is understood, however, that the outer cover 49 may instead be constructed of a single layer of liquid impermeable material, such as a thin plastic film  
25 constructed of materials such as those from which the inner layer 57 is constructed as described later herein, without departing from the scope of this invention. The liquid impermeable inner layer 57 of the outer cover 49 can be either vapor permeable (*i.e.*, "breathable") or vapor impermeable.

The bodyside liner 51 is preferably pliable, soft feeling, and nonirritating to the  
30 wearer's skin, and is employed to help isolate the wearer's skin from the absorbent body 53. The liner 51 is less hydrophilic than the absorbent body 53 to present a relatively dry surface to the wearer, and is sufficiently porous to be liquid permeable to thereby permit liquid to readily penetrate through its thickness. A suitable bodyside liner 51 may be manufactured from a wide selection of web materials, but is preferably capable of stretching in at least one  
35 direction (*e.g.*, longitudinal or lateral). In particular embodiments, the bodyside liner 51 is desirably extensible and capable of extending along with the outer cover 49 for desired fit of the diaper on the wearer.

Fastener tabs 65 (FIGs. 1 and 3) are secured to the central absorbent assembly 23 generally at the back region 29 thereof with the tabs extending laterally out from the opposite side edges 31 of the assembly. The fastener tabs 65 may be attached to the outer cover 49, to the bodyside liner 51, between the outer cover and liner, or to other components of the diaper 21. The tabs 65 may also be elastic or otherwise rendered elastomeric. For example, the fastener tabs 65 may be an elastomeric material such as a neck-bonded laminate (NBL) or stretch-bonded laminate (SBL) material.

Methods of making such materials are well known to those skilled in the art and are described in U.S. Patent No. 4,663,220 issued May 5, 1987 to Wisneski et al., U.S. Patent No. 5,226,992 issued July 13, 1993 to Morman, and European Patent Application No. EP 0 217 032 published on April 8, 1987 in the names of Taylor et al., the disclosures of which are hereby incorporated by reference. Examples of articles that include selectively configured fastener tabs are described in U.S. Patent No. 5,496,298 issued March 5, 1996 to Kuepper et al.; U.S. Patent No. 5,540,796 to Fries; and U.S. Patent No. 5,595,618 to Fries; the disclosures of which are also incorporated herein by reference. Alternatively, the fastener tabs 65 may be formed integrally with a selected diaper component. For example, the tabs 65 may be formed integrally with the inner or outer layer 57, 55 of the outer cover 49, or with the bodyside liner 51.

Fastening components, such as hook and loop fasteners, designated 71 and 72 respectively, are employed to secure the diaper 21 on the body of a child or other wearer. Alternatively, other fastening components (not shown), such as buttons, pins, snaps, adhesive tape fasteners, cohesives, mushroom-and-loop fasteners, or the like, may be employed. Desirably, the interconnection of the fastening components 71, 72 is selectively releasable and re-attachable. In the illustrated embodiment, the hook fasteners 71 are secured to and extend laterally out from the respective fastener tabs 65 at the back region 29 of the diaper 21. However, it is understood that the fastener tabs 65 may be formed of a hook material and thus comprise the hook fasteners 71 without departing from the scope of this invention. The loop fastener 72 of the illustrated embodiment is a panel of loop material secured to the outer cover 49 at the front region 25 of the diaper 21 to provide a "fasten anywhere" mechanical fastening system for improved fastening of the hook fasteners 71 with the loop fastener.

The loop material may include a pattern-unbonded non-woven fabric having continuous bonded areas that define a plurality of discrete unbonded areas. The fibers or filaments within the discrete unbonded areas of the fabric are dimensionally stabilized by the continuous bonded areas that encircle or surround each unbonded area, such that no support or backing layer of film or adhesive is required. The unbonded areas are specifically designed to afford spaces between fibers or filaments within the unbonded areas that remain sufficiently open or large to receive and engage hook elements of the complementary hook

fasteners 71. In particular, a pattern-unbonded non-woven fabric or web may include a spunbond non-woven web formed of single component or multi-component melt-spun filaments. For example, the loop material may be a laminated structure including a polyethylene component and a polypropylene component adhesively bonded together with the polypropylene component facing outward away from the outer cover 49 to receive the hook fasteners 71. Examples of suitable pattern-unbonded fabrics are described in U.S. patent No. 5,858,515 issued January 12, 1999 to T. J. Stokes et al. and entitled PATTERN-UNBONDED NON-WOVEN WEB AND PROCESS FOR MAKING THE SAME; the entire disclosure of which is incorporated herein by reference in a manner that is consistent herewith.

The diaper 21 shown in FIG. 1 also comprises a pair of containment flaps, generally indicated at 75, configured to provide a barrier to the lateral flow of body exudates. The containment flaps 75 are located generally adjacent the laterally opposite side edges 31 of the diaper 21 and, when the diaper is laid flat as shown in FIGs. 1 and 2, extend inward toward the longitudinal axis X of the diaper. Each containment flap 75 typically has a free, or unattached end 77 free from connection with the bodyside liner 51 and other components of the diaper 21. Elastic strands 79 disposed within the flaps 75 adjacent the unattached ends thereof urge the flaps toward an upright, perpendicular configuration in at least the crotch region 27 of the diaper 21 to form a seal against the wearer's body when the diaper is worn. The containment flaps 75 may extend longitudinally the entire length of the absorbent body 53 or they may extend only partially along the length of the absorbent body. When the containment flaps 75 are shorter in length than the absorbent body 53, the flaps can be selectively positioned anywhere between the side edges 31 of the diaper 21 in the crotch region 27. In a particular aspect of the invention, the containment flaps 75 extend the entire length of the absorbent body 53 to better contain the body exudates.

Such containment flaps 75 are generally well known to those skilled in the art and therefore will not be further described herein except to the extent necessary to describe the present invention. As an example, suitable constructions and arrangements for containment flaps 75 are described in U.S. Patent No. 4,704,116 issued November 3, 1987, to K. Enloe, the disclosure of which is hereby incorporated by reference. The diaper 21 may also incorporate other containment components in addition to or instead of the containment flaps 75. For example, while not shown in the drawings, other suitable containment components may include, but are not limited to, elasticized waist flaps, foam dams in the front, back and/or crotch regions, and the like.

The various components of the diaper 21 are assembled together using a suitable form of attachment, such as adhesive, sonic bonds, thermal bonds or combinations thereof. In the illustrated embodiment, the outer cover 49 and absorbent body 53 are secured to each other with lines of adhesive 81, such as a hot melt or pressure-sensitive adhesive. The bodyside

liner 51 is also secured to the outer cover 49 and may also be secured to the absorbent body 53 using the same forms of attachment.

The bodyside liner 51 may be secured to the outer cover 49 at the lateral edge margins of the crotch region 27, but at least the central portion is free of such connection. Rather than being entirely free of such connection, the bodyside liner 51 may be secured to the absorbent body 53 in the crotch region 27 by a light adhesive 83 which will break away in use. Preferably, securement of the bodyside liner 51 to the outer cover 49 is limited to overlying peripheral edge margins of the two to promote independent stretching movement of the liner and cover relative to each other. If the diaper 21 is to be sold in a pre-fastened condition, the diaper may also have passive bonds (not shown) which join the back region 29 with the front region 25.

The diaper 21 can also include a surge management layer (not shown) which helps to decelerate and diffuse surges or gushes of liquid that may be rapidly introduced into the absorbent body 53. Desirably, the surge management layer can rapidly accept and temporarily hold the liquid prior to releasing the liquid to the absorbent structure. In the illustrated embodiment, for example, a surge layer can be located between the absorbent body 53 and the bodyside liner 51. Examples of suitable surge management layers are described in U.S. Pat. No. 5,486,166 entitled FIBROUS NON-WOVEN WEB SURGE LAYER FOR PERSONAL CARE ABSORBENT ARTICLES AND THE LIKE by C. Ellis and D. Bishop, which issued Jan. 23, 1996, and U.S. Pat. No. 5,490,846 entitled IMPROVED SURGE MANAGEMENT FIBROUS NON-WOVEN WEB FOR PERSONAL CARE ABSORBENT ARTICLES AND THE LIKE by C. Ellis and R. Everett, which issued Feb. 13, 1996, the entire disclosures of which are hereby incorporated by reference in a manner that is consistent herewith.

To provide improved fit and to help further reduce leakage of body exudates from the diaper 21, elastic components are typically incorporated therein, particularly at the waist area and the leg areas. For example, the diaper 21 of the illustrated embodiment has waist elastic components 85 (FIG. 3) and leg elastics 87 (FIGs. 1 and 2). The waist elastic components 85 are configured to gather and shirr the end margins of the diaper 21 to provide a resilient, comfortable close fit around the waist of the wearer and the leg elastics 87 are configured to gather and shirr the side margins of the diaper at the leg openings 37 to provide a close fit around the wearer's legs.

Examples of other diaper 21 configurations suitable for use in connection with the instant application that may or may not include diaper components similar to those described previously are described in U.S. Patent No. 4,798,603 issued January 17, 1989, to Meyer et al.; U.S. Patent No. 5,176,668 issued January 5, 1993, to Bernardin; U.S. Patent No. 5,176,672 issued January 5, 1993, to Bruemmer et al.; U.S. Patent No. 5,192,606 issued



March 9, 1993, to Proxmire et al., U.S. Patent No. 5,509,915 issued April 23, 1996 to Hanson et al., U.S. Patent No. 5,993,433 issued November 30, 1999 to St. Louis et al., and U.S. Patent No. 6,248,097 issued June 19, 2001 to Beitz et al., the disclosures of which are herein incorporated by reference.

5           In accordance with one version of the present invention, the absorbent body 53 at least in part comprises a stabilized non-woven absorbent structure 101 (FIG. 4) formed from a mixture of absorbent fibers and binder fibers (broadly, a binding material) which are activatable as will be described to form inter-fiber bonds within the absorbent structure for stabilizing the absorbent structure. Optionally, superabsorbent material may be included in  
10           the mixture from which the stabilized non-woven absorbent structure 101 is formed. The absorbent fibers may be provided by various types of wettable, hydrophilic fibrous material. For example, suitable absorbent fibers include naturally occurring organic fibers composed of intrinsically wettable material, such as cellulosic fibers; synthetic fibers composed of cellulose or cellulose derivatives, such as rayon fibers; inorganic fibers composed of an  
15           inherently wettable material, such as glass fibers; synthetic fibers made from inherently wettable thermoplastic polymers, such as particular polyester or polyamide fibers; and synthetic fibers composed of a nonwettable thermoplastic polymer, such as polypropylene fibers, which have been hydrophilized by appropriate means. The fibers may be hydrophilized, for example, by treatment with silica, treatment with a material that has a  
20           suitable hydrophilic moiety and is not readily removable from the fiber, or by sheathing the nonwettable, hydrophobic fiber with a hydrophilic polymer during or after the formation of the fiber. For the present invention, it is contemplated that selected blends of the various types of fibers mentioned above may also be employed.

          Suitable sources of absorbent fibers may include cellulosic fibers including: wood  
25           fibers, such as bleached kraft softwood or hardwood, high-yield wood fibers, and ChemiThermoMechanical Pulp fibers; bagasse fibers; milkweed fluff fibers; wheat straw; kenaf; hemp; pineapple leaf fibers; or peat moss. High-yield fibers, such as Bleached ChemiThermal Mechanical Pulp (BCTMP) fibers, can be flash-dried and compressed into densified pads. The high-yield fiber can expand to a higher loft when wetted, and can be used  
30           for the absorbent fiber material. Other absorbent fibers, such as regenerated cellulose and curled chemically stiffened cellulose fibers may also be densified to form absorbent structures that can expand to a higher loft when wetted.

          As an example, suitable wood pulps include standard softwood fluffing grade such as NB-416 (Weyerhaeuser Corporation, Tacoma, Washington, U.S.A.) and CR-1654 (US  
35           Alliance Pulp Mills, Coosa, Alabama, U.S.A.), bleached kraft softwood or hardwood, high-yield wood fibers, ChemiThermoMechanical Pulp fibers and BCTMP fibers. Pulp may be modified in order to enhance the inherent characteristics of the fibers and their processability.

Curl may be imparted to the fibers by conventional methods including chemical treatment or mechanical twisting. Pulps may also be stiffened by the use of crosslinking agents such as formaldehyde or its derivatives, glutaraldehyde, epichlorohydrin, methylolated compounds such as urea or urea derivatives, dialdehydes such as maleic anhydride, non-methylolated urea derivatives, citric acid or other polycarboxylic acids. Some of these agents are less preferable than others due to environmental and health concerns.

Pulp may also be stiffened by the use of heat or caustic treatments such as mercerization. Examples of these types of fibers include NHB416 which is a chemically crosslinked southern softwood pulp which enhances wet modulus, available from the Weyerhaeuser Corporation of Tacoma, Washington, U.S.A. Other useful pulps are debonded pulp (NF405) also from Weyerhaeuser. HPZ3 from Buckeye Technologies, Inc of Memphis, Tennessee, U.S.A., has a chemical treatment that sets in a curl and twist, in addition to imparting added dry and wet stiffness and resilience to the fiber. Another suitable pulp is Buckeye HPF2 pulp and still another is IP SUPERSOFT® from International Paper Corporation. Suitable rayon fibers include 1.5 denier Merge 18453 fibers from Tencel Incorporated of Axis, Alabama, U.S.A.

The binder fibers are desirably activatable, such as upon being heated, to form inter-fiber bonds within the absorbent structure. As used herein, the inter-fiber bonds may be between the binder fibers and the absorbent fibers, between the binder fibers and the superabsorbent material, and/or among the binder fibers themselves.

In one embodiment, the binder fibers are bicomponent, or multicomponent binder fibers. As used herein, multicomponent fibers refers to fibers formed from two (e.g., bicomponent) or more polymers extruded from separate extruders but joined together to form a single fiber. The polymers are arranged in substantially constantly positioned distinct zones across a cross-section of the multi-component fibers and extend continuously along at least a portion of, and more desirably the entire, length of the fiber. The configuration of the multi-component fibers may be, for example, a sheath/core arrangement in which one polymer is surrounded by another, a side-by-side arrangement, a pie arrangement, an "islands-in-the-sea" arrangement or other suitable arrangement. Bicomponent fibers are disclosed in U.S. Patent No. 5,108,820 to Kaneko et al., U.S. Patent No. 4,795,668 to Krueger et al., U.S. Patent No. 5,540,992 to Marcher et al. and U.S. Patent No. 5,336,552 to Strack et al. Bicomponent fibers are also taught in U.S. Patent No. 5,382,400 to Pike et al. and may be used to produce crimp in the fibers by using the differential rates of expansion and contraction of the two (or more) polymers.

Multicomponent binder fibers as used herein refers to multicomponent fibers in which at least one of the binder fiber components has a melt temperature that is less than at least one other binder fiber component. For example, the binder fiber may be a bicomponent

fiber having a sheath/core arrangement in which the sheath component of the binder has a melt temperature that is lower than the melt temperature of the core component of the binder fiber. Upon heating of the binder fiber, the component having the lower melt temperature can fuse and bond to nearby absorbent fibers, superabsorbent material or other binder fibers while  
5 the other component, or components, remain in a generally unmelted state so as to generally maintain the integrity of the binder fiber.

In other embodiments, the binder fibers can be monofilament or homofilament fibers, biconstituent fibers and the like, as well as combinations thereof.

The binder fibers are desirably constructed of a material, or material, that are readily  
10 heated upon exposure to an activation energy, and more particularly the binder fibers are desirably susceptible to dielectric heating via exposure to electromagnetic energy wherein the binder fibers are melted to facilitate forming inter-fiber bonds within the absorbent structure.

Superabsorbent materials useful in forming the absorbent structure 101 may be chosen based on chemical structure as well as physical form. These include superabsorbent materials  
15 with low gel strength, high gel strength, surface cross-linked superabsorbent materials, uniformly cross-linked superabsorbent materials, or superabsorbent materials with varied cross-link density throughout the structure 101. The superabsorbent materials may be based on chemistries that include poly(acrylic acid), poly(iso-butylene-co-maleic anhydride), poly(ethylene oxide), carboxy-methyl cellulose, poly(-vinyl pyrrolidone), and poly(-vinyl  
20 alcohol). The superabsorbent materials may range in swelling rate from slow to fast.

The superabsorbent materials of the absorbent structure 101 of the present invention are desirably particulate. However, the superabsorbent materials may alternatively be in the form of foams, macroporous or microporous particles or fibers, particles or fibers with fibrous or particulate coatings or morphology. The superabsorbent materials may be in various length  
25 and diameter sizes and distributions and may also be in various degrees of neutralization. Counter-ions are typically Li, Na, K, Ca.

An exemplary superabsorbent material is available from Stockhausen, Inc., of Greensboro, North Carolina, U.S.A. and is designated FAVOR® SXM 880. Another exemplary superabsorbent material may be obtained from The Dow Chemical Co. of Midland,  
30 Michigan, U.S.A. under the name DRYTECH® 2035. A suitable fibrous superabsorbent material is available from Camelot Technologies, Ltd., of High River, Alberta, Canada and is designated FIBERDRI® 1241. Another suitable superabsorbent material is available from Chemtall Inc. of Riceboro, GA, and is designated FLOSORB 60 LADY®, also known as LADYSORB 60®.

35 Dielectric heating is the term applied to the generation of heat in non-conducting materials by their losses when subject to an alternating electric field of high frequency. For example, the frequency of the electric field desirably ranges from about 0.01 to about 300 GHz

(billion cycles/sec). Heating of non-conductors by this method is extremely rapid. This form of heating is applied by placing the non-conducting material between two electrodes, across which the high-frequency voltage is applied. This arrangement in effect constitutes an electric capacitor, with the load acting as the dielectric. Although ideally a capacitor has no losses, practical losses do occur, and sufficient heat is generated at high frequencies to make this a practical form of heat source.

The frequency used in dielectric heating is a function of the power desired and the size of the object being heated. Practical values of voltages applied to the electrodes are 2000 to 5000 volts/in of thickness of the object. The source of power is by electronic oscillators that are capable of generating the very high frequencies desirable.

The basic requirement for dielectric heating is the establishment of a high-frequency alternating electric field within the material or object to be heated. Once the electric field has been established, the second requirement involves dielectric loss properties of the material to be heated. The dielectric loss of a given material occurs as a result of electrical polarization effects in the material itself and may be through dipolar molecular rotation and ionic conduction. The higher the dielectric loss of a material, the more receptive to the high frequency energy it is.

In one embodiment, the electromagnetic energy is radio frequency or RF radiation, which occurs at about 27 MHz and heats by providing some portion of the total power delivered as ionic conduction to the molecules within the workpiece, with much of the remainder of the power delivered as dipolar molecular rotation.

In another embodiment, the electromagnetic energy is microwave radiation, which is dielectric heating at still higher frequencies. The predominate frequencies used in microwave heating are 915 and 2450 MHz. Microwave heating is 10 to 100 times higher in frequency than the usual dielectric heating, resulting in a lower voltage requirement if the loss factor is constant, though the loss factor is generally higher at microwave frequencies.

Microwave radiation can penetrate dielectric materials and be absorbed uniformly, thereby generating heat uniformly. Microwave energy is also selectively absorbed, offering a means for self-limiting the energy taken up by heterogeneous materials, making overheating less likely. These combined effects allow microwave heating to be more rapid, with less heating of surrounding materials, with a low thermal lag, and therefore with good control.

It is understood that the binder fibers or other suitable binding material may be activatable other than by dielectric heating, such as by convective or infrared heating or other non-thermal activation, as long as the binder fibers can be incorporated into the absorbent structure 101 prior to activation of the binder fibers to form inter-fiber bonds within the absorbent structure and then subsequently activated to form such inter-fiber bonds to thereby form the stabilized absorbent structure 101.

The binder fibers desirably have a fiber length which is at least about 0.061 mm. The

binder fiber length can alternatively be at least about 3 mm and can optionally be at least about 6 mm. In a further feature, the binder-fibers can have a length of up to about 30 mm or more. The binder fiber length can alternatively be up to about 25 mm, and can optionally be up to about 19 mm. In a further aspect, the absorbent structure 101 may include binder fibers having lengths approximating one of the dimensions (*e.g.*, length or width) of the absorbent structure. A relatively long binder fiber length provides an increased number of inter-fiber bond points upon activation of the fibers to help generate improved integrity and permeability of the absorbent structure 101.

Synthetic fibers suitable for use as binder fibers in the absorbent structure 101 include those made from synthetic matrix polymers like polyolefins, polyamides, polycaprolactones, polyetheramides, polyurethanes, polyesters, poly (meth) acrylates metal salts, polyether, poly(ethylene-vinyl acetate) random and block copolymers, polyethylene-b-polyethylene glycol block copolymers, polypropylene oxide-b-polyethylene oxide copolymers (and blends thereof) and any other suitable synthetic fibers known to those skilled in the art.

In one embodiment, an energy receptive additive can be included in the binder fibers during production thereof wherein the additive allows the binder fibers to reach their melting temperature much more rapidly than without the additive. This allows inter-fiber bonding in the absorbent structure 101 to occur at a faster rate than without the additive. The additive is desirably capable of absorbing energy at the frequency of electromagnetic energy (*e.g.*, between 0.01 GHz and 300 GHz) rapidly, such as in the range of fractions of a second, desirably less than a quarter of a second and at most about half a second. However, it is contemplated that absorbent structures which involve the absorption of energy and bonding of the binder fibers with the absorbent fibers over a period as long as about 30 seconds are intended to be within the scope of this invention. Melting of the binder fibers will depend on a number of factors such as generator power, additive receptivity, fiber denier, which is generally between 1 and 20, and the composition of the matrix polymer of the binder fiber.

The energy receptive additive may be added to a fiber-making matrix polymer as it is compounded, or coated onto the binder fiber after the fiber is produced. A typical method of compounding the additive with the matrix polymer is with a twin screw extruder, which thoroughly mixes the components prior to extruding them. Upon extrusion, the polymer blend is usually pelletized for convenient storage and transportation.

If the binder fiber is a bicomponent fiber, the energy receptive additive may be added to either or both of the fiber components. The energy receptive additive may also be added to one or more components, preferably the continuous phase, of a biconstituent fiber, and intermittently distributed throughout the length and cross-section of the fiber. If the additive to be used is not compatible with the matrix polymer into which it is to be blended, a "compatibilizer" may be added to enhance the blending. Such compatibilizers are known in

the art and examples may be found in U.S. Patent Nos. 5,108,827 and 5,294,482 to Gessner.

The energy receptive additives can be receptive to various specific spectra of energy. Just as a black item will absorb more energy and become warmer than the same item colored white when subjected to the same amount of solar energy, energy receptive additives will  
5 absorb energy at their specific wavelength, directed at them.

A successful energy receptive additive should have a dielectric loss factor, as discussed previously, which is relatively high. The energy receptive additives useful in this invention typically can have a dielectric loss factor measured in the RF or microwave frequency of between about 0.5 and 15, more particularly between about 1 and 15, and still more particularly  
10 between about 5 and 15. It should be noted that the dielectric loss factor is a dimensionless number. It is preferred that the fiber have a dielectric loss tangent of between about 0.1 and about 1, and more particularly between about 0.3 and about 0.7.

The energy receptive additive may be, for example, carbon black, magnetite, silicon carbide, calcium chloride, zircon, alumina, magnesium oxide, and titanium dioxide. The  
15 energy receptive additive may be present in an amount between 2 and 40 weight percent, and more particularly between 5 and 15 weight percent. The binder fibers may be crimped, extendible and/or elastic.

Synthetic fibers incorporating such energy receptive additives are discussed at greater length in U.S. Patent Application No. 10/034,079 filed December 20, 2001 and entitled  
20 Targeted Bonding Fibers for Stabilized Absorbent Structures, the entire disclosure of which is incorporated herein by reference. Absorbent structures incorporating binder fibers having such energy receptive additives are discussed in U.S. Patent Application No. 10/033,860 filed December 20, 2001 and entitled Targeted On-Line Stabilized Absorbent Structures.

In addition to the binder fibers having an energy receptive additive, or as an  
25 alternative thereto, the binder fibers (or at least one binder fiber component thereof where the binder fiber is a multicomponent fiber) may be constructed to have a relatively low melting temperature, such as less than about 200 °C, more desirably less than about 150 °C, even more desirably less than about 110 °C, still more desirably less than about 90 °C, and most desirably less than about 80 °C. In such an instance, the absorbent fibers and superabsorbent  
30 material of the absorbent structure 101 can act as a source of heat to indirectly transfer energy to melt the low melting temperature binder fibers. The absorbent fibers thus act as an energy receptive material, and are excited to melt the adjacent low melting temperature polymers of the binder fibers for bonding to the absorbent fibers, to the superabsorbent material and/or to each other. This melting will depend on a number of factors such as generator power,  
35 moisture content, specific heat, density of the absorbent structure 101 materials, fiber denier, which is generally between 1 and 20, and the composition and concentration of the low melting temperature polymers of the binder fibers.

The low melting temperature binder fibers desirably have a low specific heat to allow rapid heating and cooling of the absorbent structure 101. The low specific heat is useful during the heating cycle since the heat absorbed by the binder fiber before melting is relatively low. The low specific heat is also useful during subsequent cooling of the absorbent structure 101, since the heat to be removed from the binder fiber material to cause it to solidify and stabilize the absorbent structure will be lower. A suitable specific heat range of the binder fiber is in the range of about 0.1 to about 0.6 calories/gram.

The binder fibers also desirably have a high thermal conductivity to enable rapid transfer of heat therethrough. Thermal conductivity is proportional to density and heat capacity/specific heat capacity of the binder fiber material. It is beneficial to achieve higher thermal conductivity using fibers with relatively high density. For example, the binder fibers desirably have a density of more than about 0.94 grams/cubic centimeter (g/cc). This is helpful in accelerating the heating and cooling cycles during activation of the binder fibers to stabilize the absorbent structure 101. It is preferred that the thermal conductivity of the binder fibers be greater than about 0.1 joules-sec<sup>-1</sup>-mole<sup>-1</sup>-degree Kelvin<sup>-1</sup>.

Materials having a low melting enthalpy are also desirable for use as the binder fibers. The low melting enthalpy reduces the energy requirement for transformation of the binder fiber from a solid to a molten state during heating thereof and from the molten state back to a solid state during subsequent cooling. As an example, the melting enthalpy of the binder fibers is desirably less than about 100 joules/gram, more particularly less than about 75 joules/gm and still more particularly less than about 60 joules/gm.

The binder fibers also desirably have a low melt viscosity after activation, *i.e.*, once the fiber is transformed from its solid to its generally molten state. This enables the binder fiber material to flow to the junction points between the binder fibers and the absorbent fibers, superabsorbent material and/or other binder fibers for forming stable inter-fiber bonds. As an example, it is desired that the melt viscosity of the binder fibers be less than about 100,000 centipoise, more particularly less than about 20,000 centipoise and most particularly less than about 10,000 centipoise.

The binder fibers also desirably have adequate surface energy to be wettable by fluid to be absorbed by the absorbent structure 101. This wettability is not required in all applications, however, and may be accomplished using various surfactants known to those skilled in the art if the binder fiber is not intrinsically wettable.

Suitable binder fibers having a low melting temperature may be made from polyethylene-polyvinyl alcohol (PE-PVA) block or random copolymers, polyethylene-polyethylene oxide (PE-PEO) block/graft copolymers, polypropylene-polyethylene oxide (PP-PEO) block/graft copolymers, polyester, polycaprolactone, polyamide, polyacrylates, polyurethane (ester or ether based). The melting point can be adjusted by adjusting the

content of VA or PEO (for those polymers with VA and PEO) or the configuration. The binder fiber material can be made by compounding with a twin extruder, Sigma mixer or other compounding equipment and then made into fibers by conventional non-woven processes like meltblowing and spunbonding.

5           As an example, absorbent structures incorporating such low melting temperature binder fibers are discussed in U.S. Patent Application Serial No. 10/034,021, filed December 20, 2002 and entitled Absorbent Structures Having Low Melting Fibers, the entire disclosure of which is incorporated herein by reference.

10           A number of other polymers and sensitizers may also, or may alternatively, be used with the energy receptive additives in making the binder fibers. Specifically selecting and/or positioning moieties along the polymer chain can affect the dielectric loss factor of the polymer and enhance the responsiveness of the polymer to electromagnetic energy. These include polymer composites from blend, block, graft, random copolymers, ionic polymers and copolymers and metal salts. Desirably, the presence of one or more moieties along the  
15           polymer chain causes one or more of the following: (1) an increase in the dipole moments of the polymer; and (2) an increase in the unbalanced charges of the polymer molecular structure. Suitable moieties include, but are not limited to, aldehyde, ester, carboxylic acid, sulfonamide and thiocyanate groups.

20           The selected moieties may be covalently bonded or ionically attached to the polymer chain. As discussed above, moieties containing functional groups having high dipole moments are desired along the polymer chain. Suitable moieties include, but are not limited to, urea, sulfone, amide, nitro, nitrile, isocyanate, alcohol, glycol and ketone groups. Other suitable moieties include moieties containing ionic groups including, but not limited to, sodium, zinc, and potassium ions.

25           For example, a nitro group may be attached to an aryl group within the polymer chain. It should be noted that the nitro group may be attached at the meta or para position of the aryl group. Further, it should be noted that other groups may be attached at the meta or para position of the aryl group in place of the nitro group. Suitable groups include, but are not limited to, nitrile groups. In addition to these modifications, one could incorporate other  
30           monomer units into the polymer to further enhance the responsiveness of the resulting polymer. For example, monomer units containing urea and/or amide groups may be incorporated into the polymer.

35           Suitable moieties include aldehyde, ester, carboxylic acid, sulfonamide and thiocyanate groups. However, other groups having or enhancing unbalanced charges in a molecular structure can also be useful; or a moiety having an ionic or conductive group such as, *e.g.*, sodium, zinc, and potassium ions. Other ionic or conductive groups may also be used.

          Specific combinations include low density PE/polyethylene-polyvinylacetate block



copolymer, LDPE/polyethylene glycol, PE/ polyacrylates, polyethylene-vinyl acetate copolymer, polyester, polyurethane, polyacrylates, polyethylene glycol (PEG), polyacrylamide (PAA), polyethylenimine (PEEM), polyvinyl acetate (PVAC), polyvinyl alcohol (PVA), polymethylacrylic acid- sodium salt (PMA-Na), polyacrylic acid sodium salt (PA-Na), and poly (styrene sulfonate-co-methyl acrylic acid) sodium salt (P (SS-co-MA)-Na), and polymers of terephthalic acid, adipic acid and 1, 4 butanediol, and polybutylene succinate copolymers. Other materials include polymers of terephthalic acid, adipic acid and 1,4-butanediol, sold by BASF Corporation under the name ECOFLEX® or by Eastman Chemical Co. under the name Eastar Bio™ copolyester. Blends and grafted copolymers of the above listed polymers are also suitable.

Although various versions of the present invention are primarily described herein as incorporating “binder fibers”, one of skill in the art will readily appreciate that other binder materials may be utilized in the formation of the stabilized absorbent structure described herein. The term “binder material” as used herein is intended to include binder fibers and other materials which are activatable – as described herein – to form inter-fiber bonds within the absorbent structure for stabilizing the absorbent structure. Consequently, the absorbent structures of the present invention may also include a quantity of binder material such that it can be provided as a stabilized absorbent structure. The binder material can be of a polymeric or non-polymeric binder material that is capable of forming ionic bonds, covalent bonds, or physical entanglement with the fiber and/or the high absorbency material. Moreover, the binder material may be a liquid or non-liquid binder material.

Examples of suitable polymeric binders can include polypropylene glycol (PPG); polyethylene glycol (PEG); polyacrylic acid (PAA); poly(caprolactone) diol; polyamide; cationic acrylamide copolymers; polyamine; polyamide-polyamine-epichlorohydrin (KYMENE); cationic amine-epichlorohydrin wet-strength agents; polyethylene imine agents; polyamide-epichlorohydrin agents with cellulose ethers or cationic starches for improving paper wet-strength; polyacrylamides-glyoxal (*e.g.*, PAREZ); urea-formaldehyde agents (UF); cationic modified ureaformalin agents; melamine-formaldehyde agents (MF); cationic modified melamine-formalin agents; polyethylenimine (PEI); dialdehyde starch (DAS); proteinaceous adhesives treated with formaldehyde; cellulose xanthate (viscose); synthetic latexes; vegetable gums such as guar and bean gum; neutral (or alkaline-curing) thermosetting wet-strength agents; water-soluble polymers containing carboxyl groups or carboxylate ions as their alkali metal or ammonium salts; substantially non-thermosetting tertiary-amino polyamide-epichlorohydrin agents.

Some commercial liquid binders are KYMENE 557LX, a polyamidoamine modified with epichlorohydrin (available from Hercules); CREPEPLUS 75, 97, a polyamidoamine modified with low epichlorohydrin content (available from Betz Paper Chemicals);

CREPETROL 190, a polyamidoamine modified with low epichlorohydrin content (available from Hercules); PEI, polyethylenimine, molecular weight 50,000-60,000, 50 % (wt.) an aqueous liquid (available from Aldrich Chemical Co.); PEI-E a polyethylenimine modified with epichlorohydrin, base polymer mol. wt. 20,000, 17% (wt) an aqueous liquid (available from Aldrich Chemical Co.); POLYMIN PR971L, a high charge density, high molecular weight polyethylenimine (available from BASF); POLYMIN SNA, a modified high molecular weight polyethylenimine (available from BASF); and AGEFLOC WT-20VHV, a polydimethyldiallylammonium chloride (available from CPS Chemical).

Examples of non-polymeric binders can include glycerin; ascorbic acid; urea; glycine; pentaerythritol; a monosaccharide or a disaccharide; citric acid; glyoxal; tartaric acid; dipropylene glycol; and urea derivatives such as DMDHEU (dimethyldihydroxyethylurea). Suitable saccharides can include glucose, sucrose, lactose, ribose, fructose, mannose, arabinose, and erythrose.

Stabilization of the absorbent structure may also be achieved by use of emulsion binders. Physical strength can also be imparted by the use of a class of materials described herein as "latex binders." Examples of such latex binders include, but are not limited to, emulsion polymers such as thermoplastic vinyl acetate, C1-C8 alkyl ester of acrylic, methacrylic acid based adhesive, and combinations thereof. In particular, the emulsion polymerized thermoplastic adhesive can have a Tg from -25 to 20 °C, a solids content of from 45 to 60 % by weight, typically from 52 to 57 %, and a Brookfield viscosity (#4 spindle, 60 rpm at 20 °C) of from 5 to 1000 centipoises (cps). Suitable adhesives are vinyl acetate/ethylene based adhesives incorporating less than about 10 % and desirably less than 5 % by weight, of a polymerized third monomer. Representative examples of third monomers which may be incorporated into the polymer include adhesion promoting monomers such as unsaturated carboxylic acid including acrylic and methacrylic acid, crotonic acid, and epoxide containing monomers such as glycidyl acrylate, glycidylmethacrylate and the like. The Airflex 401, 405 and 410 are some examples. These binders can be obtained from Air Products and Chemicals Inc. located in Allentown, Pennsylvania, U.S.A. In addition, cross linkable binders (thermoset) may be used to impart further wet strength thereto. The thermoset vinyl acetate/ethylene binders, such as vinyl acetate/ethylene having from 1-3 % N-methylolacrylamide such as Airflex 124, 108 or 192, available from Air Products and Chemicals Inc., or Elite 22 and Elite 33, available from National Starch & Chemicals, located in Bridgeport, New Jersey, U.S.A, are examples of suitable adhesive binders.

To obtain a stabilization structure, emulsion polymerized thermoplastic polymeric adhesive may be applied to an un-stabilized fluff/superabsorbent structure in an amount ranging from 1 to 20 grams dry adhesive per square meter of substrate. In particular aspects,

5 to 15 grams of dry adhesive per square meter of substrate where the dry adhesive is applied by a spray method may provide suitable bonds.

Non-liquid binder material may also be used as a stabilizing agent. For example, binder powders may be used to stabilize absorbent structures. Binder powders for use in absorbent structures are available under the trade name VINNEX available from Wacker Polymer Systems L.P., having offices in Adrian, Michigan, U.S.A. Alternatively, thermally activated binder material, such as thermally activated binder fiber material, may be used to stabilize absorbent structures. Binder fibers are typically used in airlaid absorbent structures for higher basis weight absorbent structures, that is, greater than 120 gsm. Binder fibers generally have two components and are therefore termed bi-component fibers. Specifically, as representatively illustrated in Fig. 4, the two components include a sheath 76 and a core 78. Other suitable binder fiber configurations also include side by side, islands in the sea, and thermoplastic staple fibers. Suitable binder fibers for use in absorbent structures are available from KoSa, having offices in Houston, Texas, U.S.A., Chisso Corporation, having offices in Tokyo, Japan, and Trevira GmbH, having offices in Bobingen, Germany.

The absorbent structure 101 of the present invention is desirably of unitary construction. As used herein, the unitary construction of the absorbent structure 101 is intended to refer to configurations wherein the absorbent structure is a single non-woven web or layer comprising (i) a mixture of absorbent fibers, binder fibers and, optionally, superabsorbent material or (ii) absorbent fibers and, optionally, superabsorbent material. In the illustrated embodiment of FIGs. 1-4, a single absorbent structure 101 comprises substantially the entire absorbent body 53 of the diaper 21 (*i.e.*, the dimensions of the absorbent structure substantially define the dimensions of the absorbent body). However, it is contemplated that the absorbent body 53 may comprise more than one layer, wherein at least one of the layers is an absorbent structure 101 of the present invention, and remain within the scope of this invention as long as the absorbent structure is itself of unitary construction.

As an example, in one embodiment the absorbent structure 101 is made by first forming or otherwise collecting the absorbent fibers, superabsorbent material and binder fibers into a unitary structure having a desired shape, contour and/or material distribution prior to activation of the binder fibers (*e.g.*, prior to inter-fiber bonding within the absorbent structure) to define a non-woven, generally pre-stabilized absorbent structure. The binder fibers are subsequently activated to form inter-fiber bonds within absorbent structure to thereby stabilize the absorbent structure.

Optionally, a substantially hydrophilic tissue wrapsheet (not illustrated) may be employed to help maintain the integrity of the absorbent structure 101, or the entire absorbent body 53. The tissue wrapsheet is typically placed about the absorbent structure or the absorbent body over at least the two major facing surfaces thereof and is composed of an

absorbent cellulosic material, such as creped wadding or a high wet-strength tissue. The tissue wrapsheet can also be configured to provide a wicking layer that helps to rapidly distribute liquid to the absorbent fibers within the absorbent body 53. The wrapsheet material on one side of the absorbent body may be bonded to the wrapsheet located on the opposite side of the fibrous mass to effectively entrap the absorbent body.

In one embodiment, the material composition of the pre-stabilized absorbent structure 101 (e.g., prior to activation of the binder fibers) may be from about 0.1 to about 60 weight percent binder fiber, from about 0 to about 80 weight percent superabsorbent material, and from about 5 to about 98 weight percent absorbent fibers. More particular embodiments may have from about 2 to about 10 weight percent binder fiber, from about 30 to about 70 weight percent superabsorbent material and from about 30 to about 70 weight percent absorbent fiber. In other embodiments, the pre-stabilized absorbent structure may have from about 0.1 to about 5 weight percent binder fiber.

In another embodiment, the pre-stabilized absorbent structure 101 can include an amount of binder fibers which is at least about 0.1 weight percent with respect to the total weight of the absorbent structure. The amount of binder fibers can alternatively be at least about 1 weight percent, and can optionally be at least about 3 weight percent. In other aspects, the amount of binder fibers can be up to a maximum of about 30 weight percent, or more. The amount of binder fibers can alternatively be up to about 20 weight percent, and can optionally be up to about 5 weight percent.

The absorbent fibers, binder fibers and superabsorbent material are desirably distributed within the absorbent structure generally across the full width of the absorbent structure, along the full length thereof and throughout the thickness thereof. However, the concentration of absorbent fibers, binder fibers and/or superabsorbent material within the absorbent structure 101 may be non-uniform (i) across the width of the absorbent structure, (ii) along the length of the absorbent structure, and/or (iii) along the thickness or z-direction 127 of the absorbent structure. For example, a heavier concentration of absorbent fibers, binder fibers and/or superabsorbent material may be disposed in different strata (e.g., in the z-direction) or in different regions (e.g., along the length or across the width) of the absorbent structure.

It is also contemplated that one or more strata or regions of the absorbent structure 101 may be devoid of binder fibers and/or superabsorbent material, as long as the absorbent structure is of unitary construction and includes binder fibers in at least a portion of the structure. It is further contemplated that binder fibers constructed of different materials may be disposed in different strata or regions of the absorbent structure 101 without departing from the scope of this invention.

The average basis weight of the pre-stabilized absorbent structure 101 is desirably in

the range of about 30 to about 2500 grams/square meter (gsm), more desirably within the range of about 50 to about 2000 gsm, and even more desirably within the range of about 100 to about 1500 gsm. The pre-stabilized absorbent structure 101 can also be formed to have a non-uniform basis weight across its width or along its length, with one or more high basis weight regions, and one or more low basis weight regions. In at least one high basis weight region, at least a significant portion of the absorbent structure 101 can have a composite basis weight which is at least about 700 gsm. The high basis weight region can alternatively have a basis weight of at least about 750 gsm, and can optionally have a basis weight of at least about 800 gsm. In other aspects, the high basis weight region of the absorbent structure 101 can have a composite basis weight of up to about 2500 gsm or more. The high basis weight region can alternatively have a basis weight of less than or equal to about 2000 gsm, and more particularly less than or equal to about 1500 gsm.

Additionally, in at least one low basis weight region, the pre-stabilized absorbent structure 101 can have a composite basis weight of at least about 50 gsm. The low basis weight region can alternatively have a basis weight of at least about 100 gsm, and can optionally have a basis weight of at least about 150 gsm. In another alternative configuration, the low basis weight region of the absorbent structure 101 can have a composite basis weight of up to about 700 gsm, or more. The low basis weight region can alternatively have a basis weight of up to about 600 gsm, and can optionally have a basis weight of up to about 500 gsm.

In another aspect of the present invention, the absorbent structure 101 formed prior to activation of the binder fibers may have a density which is at least a minimum of about 0.01 g/cc as determined at a restraining pressure of 1.38 KPa (0.2 psi). The density can alternatively be at least about 0.02 g/cc, and can optionally be at least about 0.03 g/cc. In other aspects, the density may be up to a maximum of about 0.12 g/cc, or more. The density can alternatively be up to about 0.11 g/cc, and can optionally be up to about 0.1 g/cc. In one embodiment, the density of the pre-stabilized absorbent structure is substantially uniform throughout the absorbent structure. In another embodiment, the density is non-uniform across the width of the absorbent structure and/or along the length of the absorbent structure.

As used throughout the present application, the term "non-uniform" as used in reference to a particular characteristic or feature of the absorbent structure, is intended to mean that the characteristic or feature is non-constant or otherwise varies within the absorbent structure in accordance with a pre-determined non-uniformity, *e.g.*, an intended non-uniformity that is greater than non-uniformities resulting from normal processing and tolerance variations inherent in making absorbent structures. The non-uniformity may be present as either a gradual gradient or as a stepped gradient, such as where the concentration, basis weight and/or density changes abruptly from one strata or region to an adjacent strata or region within the absorbent structure, and may occur repeatedly within the absorbent structure

or may be limited to a particular portion of the absorbent structure.

The pre-stabilized absorbent structure 101 may also be formed to have a thickness which is non-uniform along the length of the absorbent structure and/or across the width of the absorbent structure. The thickness is the distance between the major faces the absorbent structure, as determined in a local z-direction of the absorbent structure directed perpendicular to the planes of the major faces thereof at the location at which the thickness is determined. A variation in thickness may be present as a gradual or otherwise sloped change in thickness or as a stepped change in thickness whereby the thickness changes abruptly from one portion of the absorbent structure to an adjacent portion.

Accordingly, one or more portions of the absorbent structure 101 can have a relatively lower thickness, and other portions of the absorbent structure can have a relatively higher thickness. For example, in the illustrated embodiment, a portion 103 (FIGs. 2 and 4) of the absorbent structure 101 which forms the absorbent body 53 of the diaper 21 is substantially thicker than the rest of the absorbent structure and corresponds generally to the front region 25 of the diaper to provide a targeted area of increased absorption capacity. The thicker portion 103 of the absorbent structure 101 extends lengthwise less than the full length of the absorbent structure and is spaced longitudinally inward of the longitudinal ends of the structure. As shown in FIG. 2 the thicker portion 103 is also centrally positioned between the side edges 105 of the absorbent structure and spaced laterally inward from the side edges thereof.

Additionally, or alternatively, the pre-stabilized absorbent structure 101 may be formed to have a non-uniform width along the length of the absorbent structure. The width is the distance between the side edges of the absorbent structure, as determined in a direction parallel to the Y-axis of the absorbent structure. A variation in width may be present as a gradual or otherwise sloped change in width or as a stepped change in which the width changes abruptly from one portion of the absorbent structure to an adjacent portion. As an example, the absorbent structure 101 may have any of a number of shapes, including rectangular, I-shaped, or T-shaped and is desirably narrower in the crotch region 27 than in the front or back regions 25, 29 of the diaper 21. As illustrated in phantom in FIG. 1, the shape of the absorbent body 53 is defined by the absorbent structure 101 and is generally T-shaped, with the laterally extending crossbar of the "T" generally corresponding to the front region 25 of the diaper 21 for improved performance, especially for male infants.

It is understood, however, that the pre-stabilized absorbent structure 101 may have a substantially uniform thickness and/or may have a substantially uniform width, *i.e.*, the side edges 105 of the absorbent structure are substantially straight and in generally parallel relationship with each other along the length of the absorbent structure.

The absorbent structure 101 is formed in accordance with a desired method for

making such an absorbent structure whereby the absorbent fibers, superabsorbent material and binder fibers are collected on a forming surface while the binder fibers are in a pre-activated condition. The absorbent structure 101 is thus formed as a unitary structure having a desired shape and contour (*e.g.*, a desired length, width and/or thickness profile) before activation of the binder fibers occurs, *i.e.*, before inter-fiber bonding occurs within the absorbent structure. The distribution of fibers and superabsorbent material within the pre-stabilized absorbent structure 101 may also be controlled during formation thereof so that the concentration of materials, basis weight and/or density is substantially non-uniform prior to activation of the binder fibers. The orientation of the absorbent fibers and binder fibers within the absorbent structure is desirably generally random following formation of the pre-stabilized absorbent structure, including at the major faces, side edges and longitudinal ends of the absorbent structure.

The binder fibers are then activated to form inter-fiber bonds with the absorbent fibers, the superabsorbent material (if present) and/or other binder fibers to stabilize the absorbent structure 101. More particularly, in one embodiment the pre-stabilized absorbent structure 101 is exposed to high-frequency electromagnetic energy (*e.g.*, microwave radiation, radio frequency radiation, *etc.*) to melt the binder fibers for inter-fiber bonding with the absorbent fibers, and then cooled to generally solidify the binder fibers to thereby secure the inter-fiber bonds between the binder fibers and the absorbent fibers.

The absorbent structure desirably remains unmolded during and after activation of the binder fibers. As used herein, the term unmolded during and after activation of the binder fibers means that the binder fibers are not subjected to an operation in which the shape and/or orientation thereof within the absorbent structure, and particularly at the major faces, side edges and longitudinal ends of the absorbent structure, is changed as a result of pressure being applied to the binder fibers while the binder fibers are heated to a generally molten or otherwise activated state. For example, in typical molding operations, the absorbent structure or at least one or both major faces of the absorbent structure is pressed against or within a mold during or after heating of the binder fibers, or the mold itself may be heated so as to heat the binder fibers. Such a molding process forces a reorientation of the absorbent structure fibers to a generally non-random orientation and, and may also re-shape or even emboss the major surfaces of the absorbent structure. Because the absorbent structure 101 remains unmolded during and after activation of the binder fibers, the orientation of fibers within the absorbent structure, including at the major faces, side edges and longitudinal ends thereof, remains generally random during and after activation of the binder fibers to stabilize the absorbent structure.

Following stabilization of the absorbent structure 101, the structure may have substantially the same shape, contour, material distribution and other characteristics as the

pre-stabilized absorbent structure. The stabilized absorbent structure 101 is desirably sufficiently strong to support a peak tensile load which is at least a minimum of about 100 grams per inch (g/inch) of cross-directional (Y-axis) width of the absorbent structure. The stabilized absorbent structure 101 strength can alternatively be at least about 200 g/inch, and can optionally be at least about 500 g/inch. In other aspects, the absorbent structure 101 strength can be up to a maximum of about 10000 g/inch, or more. The strength can alternatively be up to about 5000 g/inch, and can optionally be up to about 2000 g/inch. In determining the strength of the stabilized absorbent structure 101, any previously formed, separately provided reinforcing component should be excluded from the determination. Such reinforcing components (not shown) may, for example, be provided by a scrim, a continuous filament fiber, a yarn, an elastic filament, a tissue, a woven fabric, a non-woven fabric, an elastic film, a polymer film, a reinforcing substrate, or the like, as well as combinations thereof.

The stabilized absorbent structure 101 can be configured to have a strength sufficient to support a peak tensile load which is significantly greater than the peak tensile load that can be supported by the absorbent structure prior to activation of the binder fibers. In a particular aspect, the absorbent structure 101 can be configured to have sufficient strength to support a peak tensile load which is at least about 100 % greater than the peak tensile load that can be supported by the absorbent structure prior to activation of the binder fibers. The stabilized structure 101 can alternatively be configured to support a peak tensile load which is at least about 200 % greater. Optionally, the stabilized structure 101 can be configured to support a peak tensile load which is at least about 300 % greater. The percentage of increase in the supported peak-load can be determined by the formula:

$$100 * (F2 - F1) / F1;$$

where:

F1 = the peak tensile load that can be supported by the absorbent structure 101 prior to activation of the binder fibers; and

F2 = the peak tensile load that can be supported by the stabilized absorbent structure.

The peak load that can be supported by an absorbent structure 101 can be determined by employing TAPPI Test Method Number T 494 om-96 entitled "Tensile Properties of Paper and Paperboard" (using constant rate of elongation apparatus) dated 1996. The test sample has a width of 1 inch (2.54 cm), and a length of 6 inches (15.24 cm). The jaws used were INSTRON part number 2712-001 (available from Sintech, Inc., a business having offices in Research Triangle Park, North Carolina, U.S.A.), and were arranged with an initial separation distance of 5 inches (12.7 cm). The cross-head speed was 12.7 mm/min, and the testing employed a MTS Systems Corp. model RT/1 testing machine controlled by TESTWORKS version 4.0 software, which are available from MTS Systems Corp., a business having office



in Eden Prairie, Minnesota, USA. Substantially equivalent equipment may optionally be employed.

5 The fluid permeability of the absorbent structure 101 is also affected by the incorporation of binder fibers therein to stabilize the absorbent structure. The fluid permeability is defined by Darcy's Law and is measured for an absorbent saturated with a particular amount of fluid. More particularly, the permeability as that term is used herein is determined by the following permeability test.

10 In general, the higher the permeability of the absorbent structure when saturated, the more open the structure is. As a result, the absorbent structure can more easily take in additional fluid and is therefore less likely to leak. Without binder material, the permeability of a non-woven absorbent structure is based solely on the characteristics of the absorbent fibers and superabsorbent material, if present, and therefore has a relatively low fluid permeability, such as less than 20 square microns. The integrity of the absorbent structure 101, and more particularly the void volume thereof, is increased by stabilizing the structure with binder materials, and more particularly by multi-component binder fibers, to substantially increase the permeability of the absorbent structure. For example, following activation of the binder fibers, the stabilized absorbent structure 101 desirably has a permeability throughout the absorbent structure as measured by the above permeability test of greater than 20 square microns, more desirably greater than about 40 square microns, and even more desirably greater than about 60 square microns.

15 It is understood that the permeability may be non-uniform along at least one of the length and the width of the absorbent structure 101, as long as the local permeability of the absorbent structure is at least greater than 20 square microns. Without being bound to theory, it is also believed that an over-concentration of binder fibers within the stabilized absorbent structure can negatively affect the permeability of the absorbent structure. To facilitate increased permeability of the absorbent structure, the binder fiber concentration within the absorbent structure is desirably in the range of about 0.1 to about 10 percent, and more desirably in the range of about 0.1 to about 5 percent, to facilitate increased permeability of the absorbent structure.

25 Where the binder fibers are activated by subjecting the pre-stabilized absorbent structure 101 to dielectric heating (e.g., by exposure to electromagnetic energy), the stabilized absorbent structure also has unique physical characteristics associated with the presence of the binder fibers and subsequent activation by electromagnetic energy. These characteristics may be qualified and quantified using measurements of location and degree of oxidation and bonding efficiency within the absorbent structure. More particularly, techniques such as ultraviolet, visible, near infrared, infrared and Raman spectroscopy; surface analysis; differential scanning calorimetry; chromatographic separation; and various microscopic

techniques can demonstrate the unique properties of materials heated “externally” via convection or infrared radiant heat transfer, versus “internally” using dielectric techniques.

With infrared and convection heating, radiant energy is translated into heat at the outer surface of the absorbent structure where the surface temperature rises rapidly. Heat at the outer surface of the absorbent structure eventually diffuses via thermal conduction toward the center of the absorbent structure. This heating process is relatively slow and it takes a relatively significant time for the center of the absorbent structure to reach the threshold temperature necessary to melt binder fibers disposed toward the center of the structure. The slow process of thermal conduction is dependent upon the thermal conductivity of the structure and its overall dimensions (*e.g.*, thickness). For such a heating process, a greater oxidation of fibers consequently occurs toward, and more particularly on, the outer surface of the structure. Thermal bonding in this manner also results in some yellowing of the fibers at the outer surface of the absorbent structure.

For dielectric heating (*e.g.*, using electromagnetic energy), the peak temperature of the absorbent structure 101 is also near the outer surface. However, the temperature rise at the center of the absorbent structure 101 is nearly identical to that at the outer surface. This occurs since the dielectric heating process is active and direct. This direct transfer of energy to the center of the absorbent structure is less dependent upon thermal conductivity and more dependent upon the dielectric field strength and dielectric properties of the absorbent structure materials. In other words, the heating occurs generally from the center of the absorbent structure 101 out toward the outer surface thereof.

Infrared energy must be applied from about 3 to 30 times longer than dielectric heating to achieve generally uniform heating throughout the absorbent structure. More particularly, such an extended heating time is required in order to attain a desired temperature threshold (*e.g.*, the melting temperature of the binder fiber) at the center of the absorbent structure. When properly applied, dielectric heating occurs rapidly and more uniformly. The rapid and uniform direct heating prevents large-scale thermal degradation of polymers within the heated absorbent structure.

FIGs. 5-10 illustrate one embodiment of an apparatus, generally indicated at 121, for making an absorbent structure in accordance with the present invention and the above-described method. The apparatus 121 has an appointed lengthwise or machine-direction 123, an appointed widthwise or cross-direction 125 which extends transverse to the machine direction, and an appointed thickness or z-direction 127. For the purposes of the present disclosure, the machine-direction 123 is the direction along which a particular component or material is transported lengthwise or longitudinally along and through a particular, local position of the apparatus. The cross-direction 125 lies generally within the plane of the material being transported through the process, and is aligned perpendicular to the local

machine-direction 123. The z-direction 127 is aligned substantially perpendicular to both the machine-direction 123 and the cross-direction 125, and extends generally along a depth-wise, thickness dimension. In the illustrated embodiment, the machine direction 123 corresponds to the longitudinal X-axis of the diaper 21 of FIG. 1 and the cross-direction 125 corresponds to the lateral Y-axis of the diaper.

The apparatus 121 comprises an airforming device, generally indicated at 131 in FIGs. 5 and 6, having a movable, foraminous forming surface 135 extending about the circumference of a drum 137 (the reference numerals designating their subjects generally). The drum 137 is mounted on a shaft 139 (FIG. 7) connected by bearings 141 to a support 143. As shown in FIG. 7, the drum includes a circular wall 145 connected to the shaft 139 for conjoint rotation therewith. The shaft 139 is rotatably driven by a suitable motor or line shaft (not shown) in a counter-clockwise direction in the illustrated embodiment of FIGs. 5 and 6. The circular wall 145 cantilevers the forming surface 135 and the opposite side of the drum 137 is open. A vacuum duct 147 located radially inward of the forming surface 135 extends over an arc of the drum interior. The vacuum duct 147 has an arcuate, elongate entrance opening 149 under the foraminous forming surface 135, as will be described in more detail hereinafter, for fluid communication between the vacuum duct and the forming surface. The vacuum duct 147 is mounted on and in fluid communication with a vacuum conduit 151 connected to a vacuum source 153 (represented diagrammatically in FIG. 7). The vacuum source 153 may be, for example, an exhaust fan.

The vacuum duct 147 is connected to the vacuum supply conduit 151 along an outer peripheral surface of the conduit and extends circumferentially of the conduit. The vacuum duct 147 projects radially out from the vacuum conduit 151 toward the forming surface 135 and includes laterally spaced side walls 147A and angularly spaced end walls 147B. The shaft 139 extends through the wall 145 and into the vacuum supply conduit 151 where it is received in a bearing 155 within the conduit. The bearing 155 is sealed with the vacuum supply conduit 151 so that air is not drawn in around the shaft 139 where it enters the conduit. The brace 157 and entire conduit 21 are supported by an overhead mount 159.

A drum rim 161 (FIG. 7) is mounted on the wall 145 of the drum 137 and has a multiplicity of holes over its surface area to provide a substantially free movement of fluid, such as air, through the thickness of the rim. The rim 161 is generally tubular in shape and extends around the axis of rotation of the shaft 139 near the periphery of the wall 145. The rim 161 is cantilevered away from the drum wall 145 and has a radially inward-facing surface positioned closely adjacent to the entrance opening 149 of the vacuum duct 147. To provide an air resistant seal between the rim 161 and the entrance opening 149 of the vacuum duct 147, rim seals 163 are mounted on the inward-facing surface of the rim 161 for sliding, sealing engagement with the walls 147A of the vacuum duct. Seals (not shown) are also

mounted on the end walls 147B of the vacuum duct 147 for sliding, sealing engagement with the inward-facing surface of the rim 161. The seals may be formed of a suitable material such as felt to permit the sliding, sealing engagements.

Referring back to FIG. 6, the apparatus 121 further comprises a forming chamber 171 through which the forming surface 135 is movable conjointly with the drum 137 upon rotation thereof. More particularly, in the illustrated embodiment the forming surface 135 moves in a counter-clockwise direction within the forming chamber 171 generally from an entrance 173 through which the forming surface enters the forming chamber substantially free of fibrous material, and an exit 175 through which the forming surface exits the forming chamber with the pre-stabilized absorbent structure 101 formed thereon. Alternatively, the drum 137 may rotate in a clockwise direction relative to the forming chamber 171. The forming chamber 171 is supported by a suitable support frame (not shown) which may be anchored and/or joined to other suitable structural components as necessary or desirable.

An absorbent fiber material, such as in the form of a batt 177 (FIGs. 5 and 6) of absorbent fibers, is delivered from a suitable supply source (not shown) into a fiberizer 179, which may be a conventional rotary hammer mill, a conventional rotatable picker roll or other suitable fiberizing device. The fiberizer 179 separates the batt 177 into discrete, loose absorbent fibers which are directed from the fiberizer into the interior of the forming chamber 171. In the illustrated embodiment, the fiberizer 179 is disposed above the forming chamber 171. However, it is to be understood that the fiberizer 179 may instead be located remote from the forming chamber 171 and that absorbent fibers may be delivered to the interior of the forming chamber in other ways by other suitable devices and remain within the scope of the present invention.

Particles or fibers of superabsorbent material may be introduced into the forming chamber 171 by employing conventional mechanisms such as pipes, channels, spreaders, nozzles and the like, as well as combinations thereof. In the illustrated embodiment, superabsorbent material is delivered into the forming chamber 171 via a delivery conduit 181 and nozzle system (not shown). A binder fiber material is delivered from a suitable binder fiber supply 183, such as in the form of bales (not shown), to a suitable opening device 185 to generally separate the binder fiber material into discrete, loose binder fibers. For example, the opening device 185 may be suitable for picking, carding, planing or the like, as well as combinations thereof.

Selected quantities of binder fiber are then directed to a metering device 187, and the metering device feeds controlled quantities of the binder fiber into a binder fiber delivery conduit 189. As an example, the binder fiber metering device 187 may be a model number CAM-1X12 device which is available from Fiber Controls, Inc., a business having offices located in Gastonia, North Carolina, U.S.A. A blower 191 or other suitable device may be

employed to help the flow of binder fibers through the delivery conduit 189.

In the illustrated embodiment, the binder fiber conduit 189 delivers the binder fibers into the fiberizer 171 for generally homogenous mixing with the absorbent fibers such that a homogenous mixture of absorbent and binder fibers is subsequently delivered into the forming chamber 171. However, it is understood that the binder fibers may instead be delivered into the interior of the forming chamber 171 separate from the absorbent fibers, and at a location other than at the delivery point at which the absorbent fibers are directed by the fiberizer 179 into the forming chamber.

Where the binder fibers are directed into the forming chamber 171 at a location which is closer to the entrance 173 of the forming chamber, the binder fibers will be more concentrated toward an inner or forming surface side 193 (FIG. 6) or major face of the absorbent structure 101 formed on the forming surface 135. Where the binder fibers are directed into the forming chamber 171 at a location which is closer to the exit 175 of the forming chamber, the binder fibers will be more concentrated toward an outer or free-surface side 195 (FIG. 6) or major face of the absorbent structure 101. As an alternative, the binder fibers may be combined with or otherwise incorporated into the source of the absorbent fibers instead of being separately delivered to the airforming device 131. For instance, the binder fibers may be blended with the absorbent fibers before the absorbent fibers are formed into a supply roll (*e.g.*, the batt 177).

The foraminous forming surface 135 is defined in the illustrated embodiment by a series of mold elements, or form members 201 which are arranged end-to-end around the periphery of the forming drum 137 and independently attached to the drum. As may be seen in FIG. 8, the form members 201 each define a substantially identical pattern in which fibrous material is collected. The patterns correspond to a desired length, width and thickness of individual absorbent structures 101 which repeats over the circumference of the drum 137. However, partially repeating or non-repeating pattern shapes may be used with the present invention. It is also understood that a continuous, un-patterned absorbent structure may be formed on the forming surface 135, such as where the forming surface is flat or where the formed absorbent structure is generally rectangular, and is subsequently processed (*e.g.*, cut or otherwise formed) to a desired shape.

With general reference now to FIGs. 8-10, the form members 201 comprise a foraminous member 205 which is operatively located on and secured to the forming drum 135. The foraminous member 205 may include a screen, a wire mesh, a hard-wire cloth, a perforated member or the like, as well as combinations thereof. In the particular embodiment illustrated in FIG. 10, the foraminous member 205 is fluted to define open channels 209 which extend generally radially to allow a substantially free flow of air or other selected gas from the outer surface of the drum 137 toward the interior of the drum. The channels 209 can

have any desired cross-sectional shape, such as circular, oval, hexagonal, pentagonal, other polygonal shape or the like, as well as combinations thereof.

With particular reference to FIG. 10, the radially outermost surface defined by the foraminous member 205 can be configured with a non-uniform depth-wise (*e.g.*, z-direction 127) surface contour to provide a desired non-uniform thickness of the pre-stabilized absorbent structure 101 formed on the forming surface 135. In desired arrangements, the z-direction 127 variation of the surface contour can have a selected pattern which may be regular or irregular in configuration. For example, the pattern of the surface contour can be configured to substantially provide a selected repeat-pattern along the circumferential dimension of the forming drum 137.

The surface contour of the foraminous member 205 shown in FIG. 10 thus defines longitudinally opposite end regions having a first average depth and a central region having a second average depth that is greater than the first average depth. Each end region with the first average depth can provide a lower-basis-weight region and/or thickness of the absorbent structure 101 formed on the forming surface 135, and the central region with the greater second average depth can provide a relatively higher-basis-weight and/or thickness region of the absorbent structure. Desirably, each region with the first average depth can be substantially contiguous with an adjacent region with the greater second depth. It is also understood that the foraminous member 205 may be configured to have a z-direction 127 surface contour across the width of the forming surface 135 for providing a non-uniform basis weight and/or thickness across the width of the absorbent structure 101 formed on the forming surface.

In desired arrangements, the surface contour of the foraminous member 205 defines a generally trapezoidal shape. Alternatively, the contour may define a domed shape or may be flat. In the illustrated embodiment, the depth profile defined by the foraminous member 205 forms a pocket region 211 extending in the machine direction 123 along a portion of the length of the forming surface 135 and across a central portion of the width thereof for forming the absorbent structure illustrated in FIG. 4.

In a further aspect, one or more non-flow regions of the forming surface may be formed by employing a suitable blocking mechanism (not shown) which covers or otherwise occludes the flow of air through selected regions of the forming surface 135. As a result, the blocking mechanism can deflect or reduce the amount of fibers deposited on the areas of the forming surface 135 covered by the blocking mechanism. The blocking mechanism can optionally be configured to form other desired features of the absorbent structure 101, such as a series of key notches (not shown) on the formed absorbent structure. The key notches can, for example, provide a sensing point for locating and positioning a subsequent severing of a web of longitudinally connected absorbent structures 101 formed on the forming surface 135

into discrete absorbent structures.

Still referring to FIGs. 8-10, the form members 201 can also include one or more side-masking members 213, also sometimes referred to as contour rings, configured to provide a desired shape (*e.g.*, width profile) to the absorbent structure 101. For example, in the illustrated embodiment the side-masking members 213 are provided by a pair of laterally opposed ring members which extend circumferentially around the forming drum 137 in laterally (cross-direction 125) opposed relationship with each other. Each of the members 213 has a non-uniform inner side wall 215 along its respective length so that the laterally opposed inner side walls of the side-masking members 213 define the width profile of the absorbent structure 101 formed on the forming surface 135. More particularly, the inner side walls 215 of the side-masking members 213 have a generally serpentine contour as they extend in the machine direction 123. As a result, the side-masking members 213 provide alternating narrower and wider regions of the form members 201. Accordingly, the absorbent structure 101 delivered from the airforming device 131 can have a width profile which is non-uniform along at least a portion of the length of the structure.

In another feature, at least one of the side-masking members 213 can include one or more key tabs (not shown). The individual key tabs may, for example, be employed for marking or otherwise identifying each intended absorbent structure 101 length along the circumference of the forming drum 137. Such side-masking members 213 can be particularly advantageous when the airforming device 131 is employed to produce absorbent structures for use in disposable, shaped absorbent articles, such as diapers, children's training pants, feminine care products, adult incontinence products and the like.

It is understood that the inner side walls 215 of the side-masking members 213 can instead be generally straight (*e.g.*, parallel to the machine direction 123) to produce a substantially rectangular, ribbon shaped absorbent structure 101. It is also understood that the side edges 105 of the absorbent structure 101 can alternatively be provided by cutting and removal, cutting and folding, or the like, as well as combinations thereof.

While the forming surface 135 is illustrated herein as being part of the forming drum 137, it is to be understood that other techniques for providing the forming surface 135 may also be employed without departing from the scope of the present invention. For example, the forming surface 135 may be provided by an endless forming belt (not shown). A forming belt of this type is illustrated in U.S. Patent No. 5,466,409, entitled FORMING BELT FOR THREE-DIMENSIONAL FORMING APPLICATIONS by M. Partridge et al. which issued on November 14, 1995.

In operation to make a formed, non-woven pre-stabilized absorbent structure, *e.g.*, prior to activation of the binder fibers to form inter-fiber bonds within the absorbent structure, the vacuum source 153 (FIG. 7) creates a vacuum in the vacuum duct 147 relative to the

interior of the forming chamber 171. As the forming surface 135 enters and then moves through the forming chamber 171 toward the exit 175 thereof, the absorbent fibers, binder fibers and superabsorbent material within the forming chamber are operatively carried or transported by an entraining air stream and drawn inward by the vacuum toward the foraminous forming surface. It is understood that the absorbent fibers, superabsorbent materials and binder fibers may be entrained in any suitable fluid medium within the forming chamber 171. Accordingly, any reference herein to air as being the entraining medium should be understood to be a general reference which encompasses any other operative entraining fluid. Air passes inward through the forming surface 135 and is subsequently passed out of the drum 137 through the vacuum supply conduit 151. Absorbent fibers, binder fibers and, optionally, superabsorbent materials are collected by the form members 201 to thereby form the pre-stabilized absorbent structure 101.

It is understood that the level or strength of the vacuum suction can be selectively regulated to control the density of the absorbent structure 101 formed on the forming surface 135. A relatively greater suction strength can be employed to produce a relatively higher density, or low porosity, in the absorbent structure 101, and a relatively lower suction strength can be employed to produce a relatively lower density, or high porosity, in the absorbent structure. The specific level of suction strength will depend upon the specific flow characteristics present in the forming chamber 171. It is readily apparent that a desired suction strength can be found by employing a short, iterative series of well known trial steps. The density of the absorbent structure 101 prior to activation of the binder fibers can be important for controlling the desired functional properties of the subsequently stabilized absorbent structure.

Subsequently, the drum 137 carrying the absorbent structure 101 passes out of the forming chamber 171 through the exit 175 to a scarfing system, generally indicated at 271 in FIGs. 5 and 6, where excess thickness of the absorbent structure can be trimmed and removed to a predetermined extent. The scarfing system 271 includes a scarfing chamber 273 and a scarfing roll 275 positioned within the scarfing chamber. The scarfing roll 275 abrades excess fibrous material from the absorbent structure 101, and the removed materials are transported away from the scarfing chamber 273 within a suitable discharge conduit as is well known in the art. The removed fibrous material may, for example, be recycled back into the forming chamber 171 or the fiberizer 179, as desired. Additionally, the scarfing roll 275 can rearrange and redistribute the fibrous material along the machine-direction 123 of the absorbent structure 101 and/or along the lateral or cross-machine direction 125 of the absorbent structure.

The rotatable scarfing roll 275 is operatively connected and joined to a suitable shaft member (not shown), and is driven by a suitable drive system (not shown). The drive system



may include any conventional apparatus, such as a dedicated motor, or a coupling, gear or other transmission mechanism operatively connected to the motor or drive mechanism used to rotate the forming drum 137. The scarfing system 271 can provide a conventional trimming mechanism for removing or redistributing any excess thickness of the absorbent structure 101 that has been formed on the forming surface 135. The scarfing operation can yield an absorbent structure 101 having a selected contour on a major face-surface thereof (e.g., the free surface side 193 in the illustrated embodiment) that has been contacted by the scarfing roll 275. For example, the scarfing roll 275 may be configured to provide a substantially flat surface along the scarfed surface of the absorbent structure 101, or may optionally be configured to provide a non-flat surface. The scarfing roll 275 is disposed in spaced adjacent relationship with the forming surface 135, and the forming surface is translated past the scarfing roll upon rotation of the drum 137.

The scarfing roll 275 of the illustrated embodiment rotates in a clockwise direction which is counter to the direction of rotation of the drum 137. Alternatively, the scarfing roll 275 may be rotated in the same direction as the forming surface 135 on the forming drum 137. In either situation, the rotational speed of the scarfing roll 275 should be suitably selected to provide an effective scarfing action against the contacted surface of the formed absorbent structure 101. In like manner, any other suitable trimming mechanism may be employed in place of the scarfing system 271 to provide a cutting or abrading action to the fibrous absorbent structure 101 by a relative movement between the absorbent structure and the selected trimming mechanism.

After the scarfing operation, the portion of the forming surface 135 on which the absorbent structure 101 is formed can be moved to a release zone of the apparatus 121 disposed exterior of the forming chamber 171. In the release zone, the absorbent structure 101 is drawn away from the forming surface 135 onto a conveyor, which is indicated generally at 281 in FIGs. 5 and 6. The release can be assisted by the application of air pressure from the interior of the drum 137. The conveyor 281 receives the formed absorbent structure 101 from the forming drum 137 and conveys the absorbent structure to a collection area or to a location for further processing (not shown). Suitable conveyors can, for example, include conveyer belts, vacuum drums, transport rollers, electromagnetic suspension conveyors, fluid suspension conveyors or the like, as well as combinations thereof.

In the illustrated embodiment, the conveyor 281 includes an endless conveyor belt 283 disposed about rollers 285. A vacuum suction box 287 is located below the conveyor belt 283 to draw the absorbent structure 101 away from the forming surface 135. The belt 283 is perforate and the vacuum box 287 defines a plenum beneath the portion of the belt in close proximity to the forming surface so that the vacuum within the vacuum box acts on the absorbent structure 101 on the forming surface 135. Removal of the absorbent structure 101

from the forming surface 135 can alternatively be accomplished by the weight of the absorbent structure, by centrifugal force, by mechanical ejection, by positive air pressure or by some combination thereof or by another suitable method without departing from the scope of this invention. As an example, in the illustrated embodiment, the absorbent structures 101  
5 exiting the forming chamber are interconnected end-to-end to form a web or series of absorbent structures, each of which has a selected shape that substantially matches the shape provided by the corresponding form members 201 used to form each individual absorbent structure.

Referring now to FIG. 5, after the pre-stabilized absorbent structures 101 are  
10 transferred from the forming surface 135 to the conveyor 281, each absorbent structure is subsequently transported to an activation system 304 wherein the binder fibers are activated to form inter-fiber bonds within the absorbent structure. In one embodiment, the binder activation system 304 includes an activation chamber 306 through which each absorbent structure 101 passes, and a generator 308 for radiating electromagnetic energy within the  
15 activation chamber as each absorbent structure passes therethrough. For example, a suitable microwave generator 308 can produce an operative amount of microwave energy, and can direct the energy through a suitable wave-guide 310 to the activation chamber 306.

In one embodiment, the electromagnetic energy may be radio frequency (RF)-energy having an RF frequency which is at least a minimum of about 0.3 megahertz (MHz). The  
20 frequency can alternatively be at least about 300 MHz, and can optionally be at least about 850 MHz. In other aspects, the frequency can be up to a maximum of about 300000 MHz, or more. The frequency can alternatively be up to about 30000 MHz, and can optionally be up to about 2600 MHz. In a particular embodiment, the radio frequency is desirably about 27 MHz. In another embodiment, the electromagnetic energy may be microwave energy in the  
25 range of about 915 MHz to about 2450 MHz.

In a particular arrangement, the electromagnetic energy can operatively heat the binder fibers to a temperature above the melting point of the binder fiber material. The melted binder fibers can then adhere or otherwise bond and operatively connect to the absorbent fibers, to the superabsorbent material and/or to other binder fibers within the  
30 absorbent structure. The binder fibers may also be activated substantially without heating up the entire mass of the absorbent structure 101. In a particular feature, the binder fibers can be rapidly activated while substantially avoiding any excessive burning of the absorbent structure 101.

The heating and melt activation of the binder fibers can be produced by any operative  
35 mechanism available in the absorbent structure 101. For example, the electromagnetic energy may heat water vapor present within the absorbent structure 101, and the heated vapor can operatively melt the binder fibers. In another mechanism, the electromagnetic energy can be

absorbed by the binder fibers and the absorbed energy can operatively heat and melt the binder fibers.

5 The total residence time of the absorbent structure 101 within the activation chamber 306 can provide a distinctively efficient activation period. In a particular aspect, the activation period can be at least a minimum of about 0.002 sec. The activation period can alternatively be at least about 0.005 sec, and can optionally be at least about 0.01 sec. In other aspects, the activation period can be up to a maximum of about 3 sec. The activation period can alternatively be up to about 2 sec, and can optionally be up to about 1.5 sec.

10 The activation chamber 304 can be a tuned chamber within which the electromagnetic energy can produce an operative standing wave. In a particular feature, the activation chamber 304 can be configured to be a resonant chamber. Examples of suitable arrangements for the resonant, activation chamber system are described in a U.S. Patent No. 5,536,921 entitled SYSTEM FOR APPLYING MICROWAVE ENERGY IN SHEET-LIKE  
15 MATERIAL by Hedrick et al. which has an issue date of July 16, 1996; and in U.S. Patent No. 5,916,203 entitled COMPOSITE MATERIAL WITH ELASTICIZED PORTIONS AND A METHOD OF MAKING THE SAME by Brandon et al. which has an issue date of June 29, 1999. The entire disclosures of these documents are incorporated herein by reference in a manner that is consistent herewith. Another suitable activation system for activating the binder fibers is disclosed in U.S. Patent Application No. 10/037,385, filed December 20, 2001,  
20 and entitled Method and Apparatus for Making On-Line Stabilized Absorbent Materials.

The absorbent structure 101 exiting the activation chamber 304 can also be selectively cooled or otherwise processed following heating of the binder fibers. The cooling of the absorbent structure 101 may be provided by a cooling system that includes: chilled air, a refrigerated atmosphere, radiant cooling, transvector cooling, ambient air cooling, or the  
25 like, as well as combinations thereof. As representatively shown in FIG. 5, the cooling system may include a chilled-air supply hood 321, a vacuum conveyor 323, a blower 325 and a chiller or other refrigeration unit 327. The refrigeration unit 327 can provide a suitable coolant to a heat exchanger 329, and the blower can circulate air through the heat exchanger for cooling. The cooled air can be directed into the supply hood 321 and onto the absorbent  
30 structure 101. The air can then be drawn out of the hood 321 for recirculation through the heat exchanger 329.

In a particular aspect, the absorbent structure 101 can be cooled to a setting temperature which is below the melting temperature of the binder fiber material. In another aspect, the absorbent structure 101 can be cooled to a temperature of not more than a  
35 maximum of 200 °C within a selected setting distance downstream of the activation chamber 304. In a further feature, the absorbent structure 101 can be cooled to a temperature of not more than a maximum of 150 °C within the selected setting distance. Accordingly, the setting

distance can be measured after ending the exposure of the absorbent structure 101 to the high-frequency electromagnetic energy in the activation chamber 304. In a particular feature, the setting distance can be a minimum of about 0.5 m. The setting distance can alternatively be at least a minimum of about 0.75 m, and can optionally be at least about 1 m. In another feature, the setting distance can be a maximum of not more than about 30 m. The setting distance can alternatively be not more than about 20 m, and can optionally be not more than about 10 m.

In another aspect, an incremental portion of the heated absorbent structure 101 may be cooled to the desired setting temperature within a distinctive setting period, as determined from the time that the incremental portion of the activated structure exits the activation chamber 304. Accordingly, the setting period can be measured after ending the exposure of the absorbent structure to the high-frequency electromagnetic energy in the activation chamber 304. In a particular feature, the setting period can be a minimum of about 0.05 sec. The setting period can alternatively be at least a minimum of about 0.075 sec., and can optionally be at least about 0.1 sec. In another feature, the setting period can be a maximum of not more than about 3 sec. The setting period can alternatively be not more than about 2 sec., and can optionally be not more than about 1 sec.

The temperature of the absorbent structure 101 can be determined by employing an infrared scanner, such as a Model No. LS601RC60, available from Land Infrared, a business having offices located in Bristol, Pennsylvania, U.S.A. With this device, the temperature can be determined by aiming the measurement probe at the centerline of the structure 101, and setting up the probe (in accordance with the instruction manual) at a separation distance of 12 inches, as measured perpendicular to the structure. Alternatively, a substantially equivalent device may be employed.

The stabilized absorbent structure 101 may also be compressed (e.g., by subjecting the structure to a debulking operation) to provide a desired thickness and density to the stabilized absorbent structure. In a desired aspect, the debulking is conducted after the absorbent structure has been cooled. As representatively shown, the debulking operation can be provided by a pair of counter-rotating nip rollers 331. The debulking operation can alternatively be provided by a converging conveyor system, indexed platens, elliptical rollers, or the like, as well as combinations thereof.

In a particular aspect, the thickness of the absorbent structure following debulking can be a minimum of about 0.5 mm. The debulked thickness can alternatively be at least about 1 mm, and can optionally be at least about 2 mm. In another aspect, the debulked thickness can be up to a maximum of about 25 mm. The debulked thickness can alternatively be up to about 15 mm, and can optionally be up to about 10 mm.

In another aspect, the debulked stabilized absorbent structure 101 can have a density which is at least a minimum of about 0.05 g/cm<sup>3</sup>. The debulked density can alternatively be

at least about 0.08 g/cm<sup>3</sup>, and can optionally be at least about 0.1 g/cm<sup>3</sup>. In further aspects, the debulked density can be up to a maximum of about 0.5 g/cm<sup>3</sup>, or more. The debulked density can alternatively be up to about 0.45 g/cm<sup>3</sup>, and can optionally be up to about 0.4 g/cm<sup>3</sup>.

5 In optional configurations, the stabilized absorbent structure 101 may be cut or otherwise divided to provide a desired lateral shaping (e.g., width profile) of the structure, and/or to provide a laterally contoured structure. The cutting system may, for example, include a die cutter, a water cutter, rotary knives, reciprocating knives or the like, as well as combinations thereof. The shaping may be conducted prior to and/or after the absorbent  
10 structure 101 is subjected to the activation of the binder fiber with the selected activation system 304.

Stabilized absorbent structures such as those described herein perform quite well for their intended purposes. While conducting research into various aspects of stabilized absorbent structures, the present inventors discovered that the flexibility of stabilized  
15 absorbent structures can be enhanced by introducing discontinuous absorbent zones into at least a portion of the absorbent structure. Referring now to the absorbent structure 101 illustrated in FIGs. 11 and 12, these discontinuous absorbent zones 404 define one or more channels 400 that may run in a longitudinal length direction and/or a transverse width direction. Moreover, the present inventors discovered that the flexibility of non-stabilized  
20 absorbent structures (*i.e.*, those absorbent structure that have not been stabilized and/or those absorbent structures that are free of binder fiber) can also be enhanced by introducing discontinuous absorbent zones into at least a portion of the absorbent structure. Consequently, one of skill in the art will appreciate that many aspects disclosed herein as relating to stabilized absorbent structures are also applicable to non-stabilized absorbent structures.

25 The channels 400 are introduced into the absorbent structure 101 by inserting a forming member 402 into a foraminous member similar to foraminous member 205. Suitably, the forming member 402 is of sufficient design to allow for the formation of an absorbent structure 101, at least a portion of the absorbent structure so formed having discontinuous absorbent zones 404 that define channels 400. While one of skill in the art will readily  
30 appreciate upon reading this disclosure that a number of configurations will be effective, one particular configuration provides for a forming member 402 similar to that illustrated in FIG.13. A suitable forming member 402 may be constructed of a variety of materials as long as the materials produce a forming member having a relatively smooth surface or surfaces. A relatively smooth surface allows the absorbent structure 101 to be separated from the forming  
35 member 402 without significantly disturbing the orientation of the fibers of the absorbent structure.

An absorbent structure 101 having discontinuous absorbent zones 404 may be formed

according to a variety of methods including in the following method. Initially, a forming member 402 is inserted into a foraminous member, such as foraminous member 205 illustrated in FIGs. 8 through 10. The depth (in the z direction) of the forming member 402 will depend on the desired depth of any channel(s) 400. Once the forming member 402 is inserted, the fibers (and, optionally, the superabsorbent material) are introduced into the foraminous member 205. After the fibers – and any optional superabsorbent material – are introduced and the absorbent structure 101 having discontinuous absorbent zones 404 is formed, the absorbent structure is removed from the foraminous member 205. The absorbent structure 101 so formed may be subjected to any of a number of steps prior to stabilization (if stabilization is desired) and tailored to the intended use of the absorbent structure. In the event the absorbent structure 101 is to be stabilized, it is thereafter subjected to an appropriate method of stabilization as described herein. In an alternative approach, the absorbent structure 101 may be stabilized prior to removal of the forming member 402.

Desirably, the absorbent structures of the present invention have at least one channel 400. Any channel 400 running in a longitudinal length direction is typically spaced between the side edges 31 of the absorbent structure 101. Any such longitudinally-extending channel or channels 400 may be spaced equally or unequally between the side edges 31. Any channel 400 running in a lateral width direction is typically spaced between the waist edges 33 and 35. Any such laterally-extending channel or channels may be spaced equally or unequally between the waist edges 33 and 35.

Desirably any channel 400 extends through no less than 10; alternatively, no less than 15; alternatively, no less than 20; alternatively, no less than 25; alternatively, no less than 30; alternatively, no less than 35; alternatively, no less than 40; alternatively, no less than 45; alternatively, no less than 50; alternatively, no less than 55; alternatively, no less than 60; alternatively, no less than 65; alternatively, no less than 70; alternatively, no less than 75; alternatively, no less than 80; and finally, alternatively, no less than 85 percent of the thickness of the absorbent structure 101. In addition, any channel 400 desirably extends through no more than 90; alternatively, no more than 85; alternatively, no more than 80; alternatively, no more than 75; alternatively, no more than 70; alternatively, no more than 65; alternatively, no more than 60; alternatively, no more than 55; alternatively, no more than 50; alternatively, no more than 45; alternatively, no more than 40; alternatively, no more than 35; alternatively, no more than 30; alternatively, no more than 25; alternatively, no more than 20; and finally, alternatively, no more than 15 percent of the thickness of the absorbent structure 101. Thus, any channel 400 desirably extends through the thickness of the absorbent structure 101 in an amount ranging between no less than 10 up to no more than 90 percent; although the approximate amount may vary according to, *inter alia*, the general design and intended use of the absorbent structure.

To enjoy many of the benefits of the present invention, any channel 400 running in a longitudinal length direction desirably extends no more than 100; alternatively, no more than 95; alternatively, no more than 90; alternatively, no more than 85; alternatively, no more than 80; alternatively, no more than 75; alternatively, no more than 70; and finally, alternatively, no more than 65 percent of the longitudinal length of the absorbent structure 101. In addition, any channel running in a longitudinal length direction desirably extends no less than 20; alternatively, no less than 25; alternatively, no less than 30; alternatively, no less than 35; alternatively, no less than 40; alternatively, no less than 45; alternatively, no less than 50; alternatively, no more than 55; and finally, alternatively, no less than 60 percent of the longitudinal length of the absorbent structure 101. Thus, any channel 400 running in a longitudinal length direction desirably extends the longitudinal length of the absorbent structure 101 in an amount ranging between no less than 20 up to no more than 100 percent; although the approximate amount may vary according to, *inter alia*, the general design and intended use of the absorbent structure.

In addition, any channel 400 running in a lateral width direction suitably extends no more than 100; alternatively, no more than 95; alternatively, no more than 90; alternatively, no more than 85; alternatively, no more than 80; alternatively, no more than 75; alternatively, no more than 70; alternatively, no more than 65; alternatively, no more than 60; alternatively, no more than 55; alternatively, no more than 50; and finally, alternatively, no more than 45 percent of the lateral width of the absorbent structure 101. In addition, any channel 400 running in a lateral width direction suitably extends no less than 20; alternatively, no less than 25; alternatively, no less than 30; alternatively, no less than 35; alternatively, no less than 40; alternatively, no less than 45; alternatively, no less than 50; alternatively, no less than 55; alternatively, no less than 60; alternatively, no less than 65; alternatively, no less than 70; alternatively, no less than 75; and finally, alternatively, no less than 80 percent of the lateral width of the absorbent structure 101. Thus, any channel 400 running in a lateral width direction suitably extends the lateral width of the absorbent structure 101 in an amount ranging between no less than 20 up to no more than 100 percent; although the approximate amount may vary according to, *inter alia*, the general design and intended use of the absorbent structure.

The width (in the x-y planes, as opposed to thickness in the z plane) of any channel 400 is such that the absorbent structure 101 demonstrates the enhanced flexibility desired, but not so wide as to cause discomfort to the wearer of any disposable absorbent article incorporating the absorbent structures of the present invention. Suitably, the width of any channel 400 is no less than 0.4; alternatively, no less than 0.5; alternatively, no less than 0.6; alternatively, no less than 0.7; alternatively, no less than 0.8; alternatively, no less than 0.9; alternatively, no less than 1; alternatively, no less than 1.5; alternatively, no less than 2;

alternatively, no less than 2.5; alternatively, no less than 3; alternatively, no less than 4; alternatively, no less than 5; alternatively, no less than 6; alternatively, no less than 7; alternatively, no less than 8; alternatively, no less than 9; alternatively, no less than 9.5; alternatively, no less than 10; alternatively, no less than 10.5; alternatively, no less than 11; and finally, alternatively, no less than 11.5 mm. Suitably, the width of any channel 400 is no more than 12; alternatively, no more than 11; alternatively, no more than 10; alternatively, no more than 9; alternatively, no more than 8; alternatively, no more than 7; alternatively, no more than 6; alternatively, no more than 5; alternatively, no more than 4; alternatively, no more than 3; alternatively, no more than 2; alternatively, no more than 1; and finally, alternatively, no more than 0.5 mm. Consequently, any channel 400 suitably has a width ranging between no less than 0.4 up to no more than 12 mm; although the approximate width may vary according to, *inter alia*, the general design and intended use of the absorbent structure.

The various absorbent structures of the present invention also demonstrate an improved flexibility when compared to an otherwise similar absorbent structure free of any discontinuous absorbent zones. A stabilized absorbent structure having discontinuous absorbent zones generally has a cylindrical compression at yield which is at least 55; alternatively, at least 60; alternatively, at least 65; alternatively, at least 70; alternatively, at least 75; and finally, alternatively, at least 80 percent less than the cylindrical compression at yield of an otherwise similar stabilized absorbent structure free of any such discontinuous zone(s). Moreover, a non-stabilized absorbent structure having discontinuous absorbent zones generally has a cylindrical compression at yield which is at least 25; alternatively, at least 30; alternatively, at least 35; alternatively, at least 40; alternatively, at least 45; alternatively, at least 50; alternatively, at least 55; alternatively, at least 60; alternatively at least 65; alternatively, at least 70; and finally, alternatively, at least 75 percent less than the cylindrical compression at yield of an otherwise similar non-stabilized absorbent structure free of any such discontinuous zone(s).

One version of the present invention provides for an absorbent body suitable for incorporation into a disposable absorbent article. The absorbent body includes a non-woven absorbent structure having a unitary construction and absorbent fibers similar to those described herein. Optionally, the absorbent structure also includes superabsorbent material. The absorbent structure 101 has a longitudinal length, a lateral width and a thickness. At least a portion of the absorbent structure 101 has discontinuous absorbent zones 404 that define at least two channels 400. In this version, at least one of the channels 400 runs in a longitudinal length direction of the absorbent structure 101. Also in this version, at least one of the channels 400 runs in a lateral width direction of the absorbent structure 101. Interestingly, the present inventors also found that the density of the absorbent structure 101 in the channels



400 is less than or equal to the density of a portion of the absorbent structure adjacent the channel(s). This version of the absorbent structure 101 may either be non-stabilized or stabilized.

Another version of the present invention provides for an absorbent article comprising  
5 a fluid pervious liner, a liquid impervious outer cover and an absorbent body. The absorbent body is disposed between the liner and the outer cover. The absorbent body includes a non-woven absorbent structure having a unitary construction and absorbent fibers similar to those described herein. Optionally, the absorbent structure also includes superabsorbent material. The absorbent structure 101 has a longitudinal length, a lateral width and a thickness. At least  
10 a portion of the absorbent structure 101 has discontinuous absorbent zones 404 that define at least two channels 400. In this version, at least one of the channels 400 runs in a longitudinal length direction of the absorbent structure 101. Also in this version, at least one of the channels 400 runs in a lateral width direction of the absorbent structure 101. Interestingly, the present inventors also found that the density of the absorbent structure 101 in the channels  
15 400 is less than or equal to the density of a portion of the absorbent structure adjacent the channel(s). This version of the absorbent structure 101 may either be non-stabilized or stabilized.

Still another version of the present invention provides for an absorbent body suitable for incorporation into a disposable absorbent article. The absorbent body includes a non-  
20 woven absorbent structure having a unitary construction and absorbent fibers similar to those described herein. Optionally, the absorbent structure also includes superabsorbent material. The absorbent structure 101 has a longitudinal length, a lateral width and a thickness. At least a portion of the absorbent structure 101 has discontinuous absorbent zones 404 that define at least four channels 400. In this version, at least two of the channels 400 run in a longitudinal  
25 length direction of the absorbent structure 101. Also in this version, at least two of the channels 400 run in a lateral width direction of the absorbent structure 101. Interestingly, the present inventors also found that the density of the absorbent structure 101 in the channels 400 is less than or equal to the density of a portion of the absorbent structure adjacent the channel(s). This version of the absorbent structure 101 may either be non-stabilized or  
30 stabilized. When non-stabilized, that portion of the absorbent structure 101 having the discontinuous absorbent zones 404 has a cylindrical compression at yield which is at least 55 percent less than the cylindrical compression at yield of an otherwise similar absorbent structure free of the discontinuous absorbent zones. When stabilized, that portion of the absorbent structure 101 having the discontinuous absorbent zones 404 has a cylindrical  
35 compression at yield which is at least 30 percent less than the cylindrical compression at yield of an otherwise similar absorbent structure free of the discontinuous absorbent zones.

### EXAMPLES

The following Examples describe various versions of the invention. Other versions within the scope of the claims herein will be apparent to one skilled in the art from consideration of the specification or practice of the invention as disclosed herein. It is intended that the specification, together with the Examples, be considered exemplary only, with the scope and spirit of the invention being indicated by the claims which follow the Examples.

#### Example 1

10 In this Example, a non-stabilized absorbent structure was formed in accordance with the absorbent structure illustrated in FIG. 10, having a central region of increased thickness intermediate the side edges and longitudinal ends of the absorbent structure. The central region of the absorbent structures so formed measured 7.6 cm wide in the crotch region by 21.6 cm in length. Materials utilized were 50 % SXM 9543 superabsorbent (a superabsorbent material available from Stockhausen, Inc.) and 50 % CR-1654 pulp (available from Bowater, Inc., Greenville, South Carolina). The central region had a basis weight of 1200 gsm with all other regions of the absorbent structure having a basis weight of 300 gsm. The absorbent structure was densified in a Carver press, Model No. 4531, and available from Carver, Inc., a business having offices in Wabash, Indiana, U.S.A., using 0.1 inch shims and 20000 pounds of pressure for 90 seconds. Each sample of the absorbent structure of this Example was subjected to the Cylindrical Compression Test described below.

#### Example 2

25 In this Example, a non-stabilized absorbent structure was formed in a manner similar to that of Example 1. In this Example, however, a formed grid approximately 20.3 cm long and approximately 7.6 cm wide consisting of two wall segments running in the longitudinal direction spaced approximately 2.5 cm apart and eight wall segments running in the transverse width direction spaced approximately 2 cm apart were placed in a foraminous member similar to that illustrated in FIG. 10. The formed grid had walls approximately 0.85 mm thick and approximately 6 cm high. The entire formed grid was raised approximately 0.7 cm off the floor of the foraminous member and was similar in appearance to that illustrated in FIG. 13. Materials utilized were 50 % SXM 9543 superabsorbent and 50 % CR-1654 pulp. The central region had a basis weight of 1200 gsm with all other regions of the absorbent structure having a basis weight of 300 gsm. The absorbent structure was densified in the Carver press using 0.1 inch shims and 20000 pounds of pressure for 90 seconds. Each sample

of the absorbent structure of this Example was subjected to the Cylindrical Compression Test described below.

#### Example 3

5           In this Example, a non-stabilized absorbent structure was formed in a manner similar to that of Example 1. In this Example, however, a grid was formed by compressing a wire mesh onto the formed absorbent structure. The wire grid was formed from 2.5 mm OD copper coated welding rods and was similar in appearance to that illustrated in FIG. 14. The wire grid was otherwise similar in its spacing to that of the formed grid previously described  
10 in Example 2. The wire grid was placed on the upper or bodyfacing surface of the absorbent structure. 2000 pounds of pressure were exerted on the wire grid for about 60 seconds in the Carver press. Materials utilized were 50 % SXM 9543 superabsorbent and 50 % CR-1654 pulp. The central region had a basis weight of 1200 gsm with all other regions of the absorbent structure having a basis weight of 300 gsm. The absorbent structure was densified  
15 in the Carver press using 0.1 inch shims and 20000 pounds of pressure for 90 seconds. Each sample of the absorbent structure of this Example was subjected to the Cylindrical Compression Test described below.

#### Example 4

20           In this Example, a stabilized absorbent structure was formed in accordance with the absorbent structure illustrated in FIG. 10, having a central region of increased thickness intermediate the side edges and longitudinal ends of the absorbent structure. The central region of the absorbent structures so formed measured 7.6 cm wide in the crotch region by 21.6 cm in length. Materials utilized were 45 % SXM 9543 superabsorbent, 50 % CR-1654  
25 pulp and 5 % T-255 binder fiber, a binder fiber available from KoSa, a business having offices in Houston, Texas, U.S.A. The central region had a basis weight of 1200 gsm with all other regions of the absorbent structure having a basis weight of 300 gsm. The samples were stabilized by placing in a convective oven and heating for six minutes at 170 °C. Following stabilization, the absorbent structure was densified in the Carver press using 0.1 inch shims  
30 and 20000 pounds of pressure for 90 seconds. Each sample of the absorbent structure of this Example was subjected to the Cylindrical Compression Test described below.

#### Example 5

35           In this Example, a stabilized absorbent structure was formed in a manner similar to that of Example 4. In this Example, however, a formed grid approximately 20.3 cm long and approximately 7.6 cm wide consisting of two wall segments running in the longitudinal direction spaced approximately 2.5 cm apart and eight wall segments running in the

transverse width direction spaced approximately 2 cm apart were placed in a foraminous member similar to that illustrated in FIG. 10. The formed grid had walls approximately 0.85 mm thick and approximately 6 cm high. The entire formed grid was raised approximately 0.7 cm off the floor of the foraminous member and was similar in appearance to that illustrated in FIG. 13. Materials utilized were 45 % SXM 9543 superabsorbent, 50 % CR-1654 pulp and 5 % T-255 (0.25 inch) binder fiber. The central region had a basis weight of 1200 gsm with all other regions of the absorbent structure having a basis weight of 300 gsm. The samples were stabilized by placing in a blue convective oven and heating for six minutes at 170 °C. Following stabilization, the absorbent structure was densified in the Carver press using 0.1 inch shims and 20000 pounds of pressure for 90 seconds. Each sample of the absorbent structure of this Example was subjected to the Cylindrical Compression Test described below.

#### Example 6

In this Example, a stabilized absorbent structure was formed in a manner similar to that of Example 4. In this Example, however, a grid was formed by compressing a wire mesh onto the formed absorbent structure. The wire grid was formed from 2.5 mm OD copper coated welding rods and was similar in appearance to that illustrated in FIG. 14. The wire grid was otherwise similar in its spacing to that of the formed grid previously described in Example 5. The wire grid was placed on the upper or bodyfacing surface of the absorbent structure. 2000 pounds of pressure were exerted on the wire grid for about 60 seconds in the Carver press. Materials utilized were 45 % SXM 9543 superabsorbent, 50 % CR-1654 pulp and 5 % T-255 (0.25 inch) binder fiber. The central region had a basis weight of 1200 gsm with all other regions of the absorbent structure having a basis weight of 300 gsm. The samples were stabilized by placing in a blue convective oven and heating for six minutes at 170 °C. Following stabilization, the absorbent structure was densified in the Carver press using 0.1 inch shims and 20000 pounds of pressure for 90 seconds. Each sample of the absorbent structure of this Example was subjected to the Cylindrical Compression Test described below.

#### Cylindrical Compression Test

The Cylindrical Compression values of the foregoing Examples were evaluated. As used herein, the Cylindrical Compression Value is a measure of the dry stiffness (or flexibility) of the absorbent material. The method by which the value for edge-wise or cylindrical compression can be determined is set forth in U.S. Patent No. 6,323,388.

A 3 inch by 12 inch (7.6 cm x 30.5 cm) piece of absorbent material (or product) was cut for each example, with the longer dimension aligned with the longitudinal direction of the

product or raw material web. The example piece was formed into a cylinder having a height of 3 inches (7.6 cm), and with the two ends having 0 - 0.125 inch (0 - 3.18 mm) overlap, the sample is stapled together with three staples. One staple was near the middle of the width of the example, the other two nearer each edge of the width of the sample. The longest  
 5 dimension of the staple was in the circumference of the formed cylinder to minimize the effect of the staples on the testing.

A Sintech tester, or similar instrument was configured with a bottom platform, a platen larger than the circumference of the sample to be tested and parallel to the bottom platform, attached to a compression load cell placed in the inverted position. The specimen was placed  
 10 on the platform, under the platen. The platen was brought into contact with the specimen and compressed the sample to 50 % of its width at a rate of 25 mm/min. The force at yield obtained in compressing the sample to 50 % of its width (1.5 inches) (3.8 cm) was recorded. In addition, the energy required to compress each example to 50 % of its width was recorded.

In an example where the length of the absorbent is less than 12 inches (30.5 cm), the  
 15 Cylindrical Compression Value of the material can yet be determined. A detailed discussion of the cylindrical or edge-wise compression strength has been given in *The Handbook Of Physical And Mechanical Testing Of Paper And Paperboard*, Richard E. Mark editor, Dekker 1983, (Vol. 1). As discussed therein, for the Cylindrical Compression configuration described, the buckling stress is proportional to  $E \cdot t^2 / (H^2)$ , with the proportionality constant  
 20 being a function of  $H^2 / (R \cdot t)$  where E is the Elastic modulus, H is the height of the cylinder, R is the radius of the cylinder, and t is the thickness of the material. When expressing the stress in terms of force per basis weight, the parameter that needs to remain constant is  $H^2 / R$ . Therefore, for a sample that is smaller than 12 inches (30.5 cm), the largest possible circle should be constructed and its height (width of the sample being cut out) adjusted such that  
 25  $H^2 / R$  equals 2.1 inches (5.3 cm).

Each of the samples prepared according to the foregoing Examples was subjected to the Cylindrical Compression Test. The average values are reported in the following Table.

Example	Density (g/cm <sup>3</sup> )	Energy to 50 % (gf*mm)	Load at Yield (gf)
1	0.212	38179	1291
2	0.184	18381	517
3	0.213	36249	1208
4	0.131	59774	1438
5	0.136	39162	1010
6	0.130	40910	1138

- 5           The foregoing values indicate that a non-stabilized absorbent structure having discontinuous absorbent zones as in Example 2, has a cylindrical compression load at yield that is at least 60 percent less than the cylindrical compression load at yield of an otherwise similar non-stabilized absorbent structure free of discontinuous absorbent zones as in Example 1. Moreover, the stabilized absorbent structure having discontinuous absorbent
- 10       zones as in Example 5, has a cylindrical compression load at yield that is at least 30 percent less than the cylindrical compression load at yield of an otherwise similar stabilized absorbent structure free of discontinuous absorbent zones as in Example 4.

- 15           It will be appreciated that details of the foregoing versions, given for purposes of illustration, are not to be construed as limiting the scope of this invention. Although only a few versions of this invention have been described in rather full detail, those skilled in the art will readily appreciate that many modifications are possible in the various versions without materially departing from the novel teachings and advantages of this invention. For example, features described in relation to one version may be incorporated into any other version of the
- 20       invention.

- Accordingly, all such modifications are intended to be included within the scope of this invention, which is defined in the following claims and all equivalents thereto. Further, it is recognized that many versions may be conceived that do not achieve all of the advantages of some of the versions, yet the absence of a particular advantage shall not be construed to
- 25       necessarily mean that such a version is outside the scope of the present invention.

When introducing elements of the present invention, the articles "a", "an", "the" and

“said” are intended to mean that there are one or more of the elements. The terms “comprising”, “including” and “having” are intended to be inclusive and mean that there may be additional elements other than the listed elements.

- 5 As various changes could be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.